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June 9, 2009

Department of Environment and Natural Resources
Division of Waste Management
Solid Waste Section
401 Oberlin Road, Suite 150
Raleigh, North Carolina 27605

Attention: Mr. Ervin Lane

Reference: Revised Water Quality Monitoring Plan
City of Durham Closed Municipal Solid Waste Landfill
Permit No. 32-01
Durham County, North Carolina
S&ME Project No. 1054-07-469

Dear Ervin:

On behalf of the City of Durham, S&ME, Inc. (S&ME) is submitting the enclosed *Water Quality Monitoring Plan* (WQMP) which documents the proposed revisions to the water quality monitoring network at the closed City of Durham municipal solid waste (MSW) landfill (DWM Permit No. 32-01). The revised WQMP has been developed and is aligned with current solid waste section guidelines for the above-referenced facility following the conclusions and recommendations presented in the November 2008 semi-annual monitoring report (S&ME, February 2008).

Many significant changes have occurred at the City of Durham's MSWLF with regard to the groundwater monitoring well network since the original WQMP was submitted by Malcolm Pirnie, Inc. in April 1994. One of the most notable changes at the landfill was the City's decision to stop accepting waste at the facility and the subsequent closure in 1997. S&ME has evaluated the water quality monitoring network at the site over the course of the last three sampling events. It is our opinion that the current water quality monitoring network does not adequately enable early detection of groundwater contamination that may originate from the landfill in the uppermost aquifer.

It has been determined that several of the down-gradient compliance monitor wells were located either in or near the delineated waste boundary, leading to exceedances of groundwater protection standards and unnecessary Appendix II sampling. The current monitor well network configuration places unbalanced attention on the up-gradient and cross-gradient compliance points, while leaving several down-gradient areas between the landfill and Ellerbee Creek open to migration of groundwater contamination.

The goal of the revised WQMP is to implement a monitoring well network that will adequately represent current groundwater conditions at the facility while relocating primary compliance points away from the delineated waste boundary in an attempt to remove false positive exceedances produced from sampling wells that are too close to the waste boundary.

S&ME respectfully request conditional approval of the interim WQMP by the Solid Waste Section as soon as possible so that we may install four replacement wells and properly abandoning two wells (located in or near waste) ahead of the upcoming June 2009 Semiannual Groundwater Monitoring Event. A relatively quick turnaround of the review of this plan and conditional approval will allow us adequate time to revise the monitor well network and have the new wells installed and surveyed prior to the June 2009 sampling event. Upon completion of the new monitor well network and sampling, S&ME will submit a final version of the WQMP with the newly installed well construction details and surveyed locations.

Please call us at (919) 872-2660 if you have any questions regarding the information presented in this report, or if we can be of further assistance.

Sincerely,
S&ME, Inc.

Gerald Paul
Environmental Staff Professional

Samuel P. Watts, P.G.
Senior Project Manager

cc: Ms. Nancy L. Newell, P.E. - City of Durham, Department of Water Management

Enclosure: *June 2009 – Water Quality Monitoring Plan - City of Durham Municipal Solid Waste Landfill,* dated June 9, 2009.

JUNE 2009
WATER QUALITY MONITORING PLAN

City Of Durham
Municipal Solid Waste Landfill
Durham, North Carolina
(DWM Permit No. 32-01)
S&ME Project Number 1054-07-469

Prepared for:

City Of Durham
Department of Water Management
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June 9, 2009

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1.0 INTRODUCTION

The following Water Quality Monitoring Plan (WQMP) summarizes the activities and protocol recommended to perform monitoring at City of Durham closed municipal solid waste (MSW) landfill in general accordance with the requirements as specified in the North Carolina Department of Environment and Natural Resources (NCDENR) Solid Waste Management Rules, Sections .0600 and .1637(a)(1) of 15A NCAC 13B. The WQMP is designed to monitor groundwater and surface water quality in order to detect a release from the landfill into the uppermost aquifer [.1623(b)(3)(C)]. This plan was developed by S&ME, Inc under contract with the City of Durham to provide engineering services (CT 2889, dated October 22, 2007) and S&ME Proposal No. P4181-07V, dated August 20, 2007.

This two part water quality monitoring plan consists of a Monitoring System Plan and Sampling and Analysis Plan. The Monitoring System Plan described in Section 2.0 of this document includes a hydrogeologic study that describes the regional and local hydrogeology at the City of Durham's Closed Municipal Solid Waste Landfill (MSWLF). Also included in the Monitoring System Plan is a description of the current water quality monitoring network and associated well construction and maintenance related information.

The Sampling and Analysis Plan is described in Section 3.0 of this document. This section includes a discussion of the sampling locations, frequency of sampling, and sampling procedures. Also included in the Sampling and Analysis Plan is a description of the analytical methods that will be utilized for the analysis of collected samples, data management protocols, and a discussion of quality assurance/quality control measures, and the statistical procedures used to evaluate the data.

The City of Durham Landfill is a closed municipal solid waste (MSW) landfill and is maintained by the City of Durham's Department of Water Management under Permit No. 32-01 issued by the North Carolina Department of Environment and Natural Resources, Division of Waste Management (NCDENR-DWM).

Section 4.0 of this document discusses the requirements for reporting the sampling results to NCDENR.

The subject facility is a closed, unlined MSW landfill that ceased accepting wastes in 1997. Groundwater and surface water has been monitored at the facility since September 1994 in general accordance with the *City of Durham Sanitary Landfill Water Quality Monitoring Pla*n, prepared by Malcolm Pirnie, Inc. in April 1994 (MP 1994). The vicinity location of the facility is shown on **Figure 1,** with more details of the Facility and the immediate area shown on **Figure 2**. The landfill is located northeast of downtown Durham, near the North Durham Water Reclamation Facility (NDWRF) off East Club Boulevard at Glenn Road. The original WQMP (MP 1994) and historical groundwater and surface water quality data from the site were considered in developing this updated WQMP.

2.0 MONITORING SYSTEM PLAN

2.1 HYDROGEOLOGIC STUDY

2.1.1 Regional Geology

The City of Durham Closed MSW landfill is located within the Deep River Basin, which is an extensional basin consisting of sedimentary deposits formed during the Triassic and Jurassic. The Deep River Basin extends along the east coast of North and South Carolina for 90 miles, from the South Carolina state line near Wadesboro, Anson County, northeastward to near Oxford, Granville County. The basin is bound by normal block-faults along the basin margins. A series of three interconnected sub-basins have been identified within the Deep River Basin. From north to south they are the Durham, Sanford, and Wadesboro sub-basins. The Durham Landfill lies entirely within the boundaries of the Durham sub-basin.

The sedimentary rocks of the Deep River Basin are part of the Chatham Group, which is divided into three formations: the Pekin, which occurs along the northwestern boundary of the basin; the Cumnock, which occurs in the middle of the basin; and, the Sanford, which occurs along the southeastern boundary of the basin. The formations are divided based on a lateral progression away from the western boundary of the basin rather than a vertical sequence. All three formations belong to the Triassic aged Newark Supergroup. The Durham sub-basin is composed of bedrock of the Pekin formation which consists of arkosic sandstones, siltstones, and mudstones (Stewart, Ballard, and Black, 1989; Huber and others, 1993). Within the Durham sub-basin, the bedrock is informally referred to as "Lithofacies Association I, II or III" (Huber and others, 1993). The total thickness of sedimentary rocks is estimated to be approximately 6,000 feet. Within the Durham sub-basin, the sedimentary rocks are generally characterized as massively bedded, approximately 15 feet thick, dipping towards the east at 20 to 30 degrees. Some thinner beds, approximately four to six feet thick, may be present in localized areas (Hoffman and Gallagher, 1989).

2.1.2 Site Geology

The northwestern boundary of the Durham Basin is estimated to be approximately five miles northwest of the landfill and the southeastern boundary is over 15 miles southeast of the landfill (Stewart, Ballard, and Black, 1989). No fault has been identified along the northwestern boundary of the basin. The Jonesboro Fault along the southeastern boundary of the basin is over 15 miles southeast of Durham, North Carolina. An unnamed, normal block-type fault occurs approximately 10 to 12 miles southeast of the site as noted on the Southeast Durham Geologic Quadrangle (Hoffman and Gallagher, 1989). The bedrock underlying the site consists of mudstone, siltstone, and sandstone, based on observations reported in published reports for the Durham sub-basin (Fleck and White, 1989). The overburden is typically saprolite, formed from the weathering of the

bedrock. Saprolitic soils generally resemble the original parent material in texture and composition of the more resistant minerals (e.g., quartz).

Soils

The soils around the landfill consist principally of White Store sandy loams in the upland areas (north, south, and east of the landfill), and Chewacla and Wehadkee soils near Ellerbe Creek (west of the landfill). Also present are Roanoke soils to the southwest and north west, Altavista silt loams, and Creedmoor sandy loams (Soil Survey of Durham County). The White Store, Altavista, and Creedmoor soils are all upland soils, occurring at the higher elevations and on slopes. The White Store soils are typically moderately well drained, low permeability, and high shrink-swell capacity and weather from Triassic mudstone. The Altavista soils are formed from weathered Triassic mudstone and generally have a finer texture than the White Store soils. These soils have hydraulic properties similar to the White Store soils and a lower shrink-swell capacity. The Creedmoor soils are also formed from weathered Triassic mudstone and have a similar texture as the White Store soils but with a lower shrink-swell capacity. The higher shrink-swell capacity of the White Store soils can result in cracks in the soil at the surface. These cracks typically extend only into the B-horizon, where the shrink swell cycle is less frequent and soil from the overlying A-horizon is deposited through illuviation. The principal effect of the higher shrink-swell capacity is to increase the infiltration rates. The Chewacla-Wehadkee association and the Roanoke soils occur on flood plains and consist of somewhat poorly drained loamy soils with low to moderate permeability. These soils are typically formed from alluvial deposits and not from weathering of the underlying bedrock. The groundwater table in these soils is typically high, between one and two feet beneath the surface.

Saprolite

The City of Durham Closed MSW landfill site is underlain by greater than 80 feet of saprolite and weathered rock in the eastern portion of the site with a gradational transition zone of soil and weathered rock to competent rock, based on site boring logs. In the western portion of the site, in the floodplain near Ellerbe Creek, the saprolite is approximately 25 feet thick. Based on soil borings from the original monitoring wells MW-3, MW-4, and test borings P-l, P-2, P-3, P-4, and MW-2, the unconsolidated overburden at the site consists of sediments derived from the weathering of the underlying Triassic aged mudstones and siltstones of the Pekin Formation (MP 1994). The saprolite consists primarily of fine sand to silt with minor percentages of medium-sand and clay. Based on the boring logs, there does not appear to be any laterally continuous, well-defined layers of clay. The saprolite is consistently composed of fine-sand to silt which is a typical weathering product of siltstone.

Bedrock

The bedrock units underlying the site belong to the Pekin Formation, which consists of arkosic sandstones, siltstones, and mudstones (Stewart, Ballard, and Black, 1989; Huber

and others, 1993). The Pekin Formation has been locally sub-divided into three lithofacies associations (Huber and others, 1993). Contact between the lithofacies is gradational, and the landfill is located near the gradational contact between Lithofacies I and II. No mappable faults have been identified within the area of the landfill. The closest mappable fault is the Jonesboro Fault located approximately 15 miles southeast of Durham, North Carolina and an unnamed, normal block-type fault approximately 10 to 12 miles southeast of the site.

2.1.3 Site Hydrogeology

Surface Water

Surface water features appear to influence local groundwater flow around the landfill. From previous sampling events groundwater has been observed to flow in a radial direction away from the landfill toward surface water features to the northwest, west, and southwest. The dominant surface water feature is Ellerbe Creek, which flows past the western border of the landfill. Ellerbe Creek is a major tributary of the Neuse River and serves as the principal drainage basin in the area around the landfill. Intermittent streams, which are tributaries of Ellerbe Creek, are located near the northern and southern edges of the landfill.

The stream to the north branches at the northeast corner of the landfill, with one branch extending to the southeast, partially encircling the landfill. The headwater of this branch is a pond located approximately 550 feet east of the landfill edge.

The intermittent stream to the south of the landfill acts as a surface drainage feature for the low-lying wetland areas that encircle the landfill along the southern and southeastern compliance boundaries see **Figure 2**.

Groundwater

The water table aquifer at the landfill is contained within the saprolite and the underlying transition zone to unweathered bedrock. The saprolite consists primarily of sand which would have a higher permeability and transmissivity than the underlying bedrock. Studies performed on the hydraulic effects of remnant structure within saprolite units indicate that remnant structures influence groundwater flow. These studies indicate that groundwater flows preferentially along remnant structures within the saprolite such as foliated zones (Fleck and White, 1989) or, as may be the case of the City of Durham Closed MSW landfill, along more permeable layers derived from weathering of coarser-grained bedrock.

The bedrock underlying the landfill consists of massively bedded mudstone, sandstone, and siltstone and has been noted to contain only minor fracturing. Based on this information, the dominant groundwater flow path should be horizontal, through the more permeable saprolite and transition zone. Groundwater elevations from on-site wells and surface water elevations provide information on groundwater flow direction. The

regional direction of groundwater flow in this area appears to be to the west toward Ellerbe Creek. There also appears to be a local groundwater flow component toward the streams adjacent to the landfill and away from the pond east of the landfill. This results in a general radial flow direction away from the landfill and toward the streams leading to Ellerbe Creek. Groundwater flow near the western and northern boundary appears to be west-northwest, toward Ellerbe Creek and its unnamed tributary north of the landfill. On the northeast and east side of the landfill, groundwater flow appears to be to the northeast, toward the stream on the northeast side of the landfill. Along the southern border of the landfill, groundwater flow appears to be in a south-southwest direction, toward the perennial stream located south of the landfill.

Hydraulic Conductivity and Groundwater Flow Velocity

As described in the *City of Durham Sanitary Landfill Water Quality Monitoring Plan*, (MP 1994) in-situ hydraulic conductivity (slug tests) were conducted in three monitor wells in March 1994 (MW-2, MW-3 and MW-4). Based on these tests, the hydraulic conductivity varied between $8x10^{-5}$ cm/sec (centimeters per second) to $4x10^{-3}$ cm/sec.

In May 2008 S&ME, Inc. conducted in-situ hydraulic conductivity (rising head tests) in monitoring wells MW-2, MW-3R, MW-4R, MW-5, MW-7R, MW-8, and MW-9R. Rising head tests were conducted to estimate hydraulic conductivity within the sediments in the surficial water bearing zone at those locations. The test data from the rising head tests were analyzed by the Bouwer and Rice Method as described in the *May 2008 Monitoring Report - Semi-Annual Monitoring of Groundwater And Surface Water*, July 30, 2008 prepared by S&ME, Inc. (S&ME, July 2008). The calculated hydraulic conductivity (K) values at the site ranged from $4.59x10^{-5}$ cm/sec to $3.48x10^{-4}$ cm/sec. Results of the rising head tests are presented in **Appendix I.** Corresponding hydraulic conductivity (K) values are summarized in **Table 1**.

The horizontal groundwater flow velocity within the monitored zone of the uppermost aquifer beneath the facility was estimated based on the measured hydraulic conductivity, assumed effective porosity based on grain size, and a hydraulic gradient established from existing wells using the following modified Darcy equation:

$$V = Ki/ n_e$$

Where: V = average seepage velocity (feet/year),
K = hydraulic conductivity (feet/year),
i = horizontal hydraulic gradient, and
n = effective porosity.

The horizontal gradient was taken from the static water levels measured during the November 2008 semi-annual monitoring event (S&ME, February 2009). Although water levels, and corresponding hydraulic gradients, vary seasonally, the November 2008 water levels are similar to previous sampling events and may be considered representative for the site.

Effective porosity (n) was taken from published values of porosity for sands and silts. For a conservative estimate (higher flow velocity), the lower range of porosity was used. The reported values of porosity for sand range between 0.20 and 0.35 (EPA 625/6-87-016, and Fetter, 1980). To provide a higher estimated flow velocity, the n of 0.2 was used.

Based on the available data, groundwater flow velocity for the wells range from a low of 5.38 ft/yr (feet per year) at MW-7R to 45.88 ft/yr at MW-8. Estimated groundwater flow rates are summarized on **Table 2**.

2.2 GROUNDWATER MONITORING SYSTEM

2.2.1 Monitor Well Network

The facility's monitoring network consists of sixteen (16) monitor wells/piezometers. Of the 16 wells/piezometers at the site, nine (9) are used to measure water levels only (MW-3R, MW-4R, MW-7R, MW-8, MW-10, PZ-2R, PZ-3, PZ-4R, and PZ-6). These wells will remain intact to support future water quality studies. A copy of the available well construction boring records and soil boring logs is included in **Appendix II**. Due to the age of several monitor wells and lack of historical information, several of the well/piezometer boring logs and well construction records could not be found. However, a summary of the construction details for the other monitor wells and piezometers installed in the vicinity of the landfill are included and summarized in **Table 3**.

Monitor wells MW-2 and MW-5 were installed by Law Engineering in 1995. Monitor well MW-4R was installed by Fishburne, Inc. in 1999. Monitor wells MW-3R, MW-7R, MW-8, and MW-9R were installed by NFE Technologies, Inc. in 2004. Monitor Well MW-10 was installed by S&ME, Inc. in August 2008. Four new monitor wells (MW-11, MW-12, MW-13 and MW-14) will be installed upon approval of this WQMP by DWM. A summary of the construction details for the monitor wells and piezometers are included in **Table 3**. A summary of the surveyed northings, eastings and top of casing elevations is included in **Table 4**. All monitor well and piezometer locations, existing and proposed, are illustrated on **Figure 2**.

The seven (7) wells used to monitor groundwater quality will consist of one up-gradient/background monitor well (MW-9R) and six (6) down-gradient compliance monitor wells (MW-2, MW-5, MW-11, MW-12, MW-13 and MW-14).

- MW-2 and MW-5 are existing wells that are located along the north and northwest permitted facility boundary.
- MW-11, MW-12, MW-13 and MW-14 will be installed along the west permitted facility boundary approximately between the facility and Ellerbe Creek.
- MW-9R is located directly east beyond the eastern compliance boundary of the landfill and serves as a background water quality monitoring location.

Water Quality Monitoring Network
Groundwater Sampling Locations

Background Monitor Well	Compliance Monitor Wells
MW-9R	MW-2
	MW-5
	MW-11*
	MW-12*
	MW-13*
	MW-14*

* These wells to be installed upon approval of WQMP

Monitor well MW-9R is located approximately 440 feet up-gradient of the apparent waste boundary. The existing and proposed compliance wells, MW-2, MW-5, MW-11, MW-12 MW-13 and MW-14 are within the relative point of compliance ranging from 45 feet to 200 feet from the apparent waste boundary. The down-gradient monitoring wells appear to be located in areas along the primary downgradient components of flow for the landfill and are strategically located to enable early detection of groundwater contamination that may originate from the landfill and travel in the uppermost aquifer.

The existing wells/piezometers that will be used to monitor groundwater at the site have been constructed in accordance with the North Carolina Well Construction Standards (15A NCAC 2C .0108) and the requirements of the North Carolina Water Quality Monitoring Guidance Document for Solid Waste Facilities. These wells have been constructed of two-inch diameter PVC well screen and casing. The screened section of each well intercepts the groundwater table with a PVC well screen with a slot size of 0.010 inch. The horizontal location of the well and the vertical elevation of the top of the casings of all monitor wells and piezometers have been surveyed under the direction of a Professional Surveyor, licensed in North Carolina to the State Plane coordinate system relative to the NAD 83 control datum and to the National Geodetic Vertical Datum (NGVD 29). A typical monitoring well construction detail for a Type II monitoring well is included as **Figure 3**.

2.2.2 Well Installation Procedures - New Monitor Wells

Future monitor wells constructed at the facility will be Type II wells constructed in accordance with the North Carolina Well Construction Standards (15A NCAC 2C .0108) and the requirements of the *North Carolina Water Quality Monitoring Guidance Document for Solid Waste Facilities*. Boreholes will be drilled and the wells will be constructed by a North Carolina licensed well driller. Equipment used for drilling and completion of the wells will be properly cleaned prior to use at each location. At a minimum, this will consist of high pressure steam cleaning of the down-hole drilling equipment prior to drilling each boring. Boreholes will be a minimum of six inches in diameter. Lithologic samples should be collected during advancement of the borings for visual classification of the stratigraphy.

New monitor wells will be constructed of two inch I.D., NSF Grade PVC (meeting ASTM D-178S and F480 requirements) schedule 40 flush-joint threaded casing and 0.01-inch machine slotted screen. Only casing with water-tight joints will be used. All well construction materials will be thoroughly cleaned prior to installation or will be installed directly from factory sealed packaging. Once the borehole has been drilled, the project manager will approve the monitoring well construction based on site-specific hydrogeologic conditions and the following general criteria:

The upper surficial aquifer monitoring well screen intervals will be 10 to 15 feet in length and located so that the estimated seasonal high water table is just below the top of the screened interval. For areas with high groundwater levels (i.e., less than five feet below land surface), the top of screen will be placed at a depth of five feet below land surface to allow adequate space for a seal and to allow sufficient space for grout and a concrete collar to secure the protective casing.

The annular space between the borehole wall and the well casing will be backfilled with clean, well rounded, washed, high grade, screen sized #2 silica sand. The sand pack will be placed approximately two feet above the slotted screen using a tremie pipe. A minimum of one foot of sand above the screen may be used where the top of the screen depth is shallow to allow for an adequate seal. The hollow stem augers, if used, will be incrementally withdrawn while the filter pack is placed. The filter pack level will be frequently sounded and kept at the base of the augers or temporary casing until the desired length of filter pack is in place.

A minimum of one foot pelletized bentonite seal will be placed above the filter pack and appropriately hydrated with clean water. The bentonite seal will be placed with a tremie pipe unless conditions prevent such use. The bentonite pellets will be carefully tamped into a wet, cohesive clay mass before placement of the grout seal. Care will be taken so that the augers or temporary steel casing is withdrawn above the top of the pellets to prohibit the bentonite pellet seal from sticking to the auger or casing.

The remainder of the annular space will be filled with a cement grout from the top of the bentonite seal to near (approximately three feet below) ground surface. The grout will be slowly pumped through a tremie pipe at a constant rate to prevent dilution or differential settling. The cement is to be mixed with six gallons of potable water for each 94 pound sack of Type I Portland cement. No aggregate materials are to be included in the slurry. The tremie pipe will be removed as the grout is placed in the borehole. Subsequent to set up, additional grout may be required for "topping off" the grout seal to near ground surface. After grouting, no work will be permitted on the well for a minimum of 24 hours while the grout is setting.

A four inch square steel protective casing with a locking cap will be placed over the well riser pipe. The protective casing will extend no more than three feet above ground surface. The protective casing will be placed on the well casing following the initial grouting. The protective casing will be sealed and immobilized in a concrete pad placed around the protective casing.

The protective casing will be primed, painted, and provided with a permanently affixed name plate with the following information as required in the well standards:

- Well identification number
- Driller registration number
- Total depth of well
- Depth of screen interval
- Depth to groundwater following well completion
- A warning that the well is not for water supply and that the groundwater may contain hazardous materials

A concrete slab or pad sloping gently away from the well in all directions will be constructed. The slab will serve as anchorage and to prevent surface water from migrating along the wall of the casing. The concrete pad dimensions will be at a minimum 2 feet wide by 2 feet long by 4 inches thick.

The location, installation methods, and construction details of the wells may be modified depending on field conditions (i.e. shallow groundwater). Any modifications, other than for high groundwater conditions, will be discussed with NC Solid Waste Section prior to the construction of the monitoring well requiring modifications.

The groundwater monitoring system described in these plans will be installed under the supervision of a geologist or engineer licensed to practice in the State of North Carolina.

The following information will be recorded during the construction of wells and maintained by the owner:

- Name of driller, identification of drill rig
- Date of construction
- Drilling method
- Borehole diameter and well casing diameter
- Well depth (±0.1 ft.)
- Drilling logs (including lithology)
- Casing materials
- Casing and screen materials and design
- Filter pack material, size, volume and placement method
- Sealant materials, volume, and placement method
- Surface seal design/construction
- Well development procedures
- Type of protective well casing
- Well location (±0.5 ft.), ground surface and top of casing (TOC) elevation (±0.01 ft.)

All monitor wells installed at the facility shall be constructed by a well driller certified by the North Carolina Well Contractors Certification Commission (ref. NCAC 15A 27) and

shall be constructed in accordance with North Carolina Well Construction Standards (ref. NCAC 15A 2C). All monitor wells installed at the facility shall be surveyed under the direction of a Professional Surveyor licensed in North Carolina relative to the State Plane coordinate system referenced to the NAD 83 datum and the National Geodetic Vertical Datum (NGVD 29).

2.2.3 Well Development

Following well installation, new monitoring wells will be developed using a bailer, pump, surge block, or combination of these instruments to remove clay, silt, sand and other fine materials that may have been introduced into the formation or sand pack during drilling and well installation. Proper well development will also establish equilibrium of the well within the aquifer. Well development will be performed no sooner than 24 hours after well construction is complete and will continue until the suspended solids are removed from the sand pack and well, and until turbidity is reduced to acceptable levels, if possible.

Due to the nature of saprolitic aquifers, zones of naturally high turbidity do exist within water table aquifers throughout the southeastern United States, which may not be attributed to the influence of the landfill. These zones often exist along localized rapid transitional boundaries within the aquifer between areas of high hydraulic head to areas of low hydraulic head. It is important to note that in some instances the selected location for a newly installed groundwater monitoring well may be situated within a naturally turbid zone within the uppermost pervasive aquifer. If this case is encountered during future well installations and efforts to reduce the turbidity within the well fail, and it is deemed that the natural turbidity may affect the groundwater quality results from that location, a new location will be selected and a new monitoring well installed.

2.2.4 Well Maintenance

The wells and surrounding area will be maintained in such a way to ensure access to the wells for sampling and to maintain the integrity of the wells. The monitoring wells will be accessible by at least a four-wheel drive vehicle. Brush and weeds will be cleared from around the wells (minimum of 10-foot radius). The well protective casings will be painted with high visibility color paint. Surface water run-off controls will be installed, where necessary, to prohibit erosion of or undermining of the concrete pads. The concrete pads will be monitored at least semi-annually for integrity and repairs performed as needed. At each monitoring well, the following items will be checked regularly to ensure the wells are properly maintained:

- Surface water is diverted away from the well head.
- The concrete pad is intact and free of cracks.
- Surface water has not undercut the concrete pad.
- The outer casing is secured and locked.
- The well identification tag is legible.

- The grout between the inner and outer well casings is all the way to the ground surface.
- The inner well casing is firmly grouted in place.
- The inner and outer well casings remain upright and unobstructed.
- Monitoring wells are visible and adequately protected from moving equipment and obstruction due to brush and weeds.

Additional inspection items, which should be performed at the time of sample collection, are described in Section 3.4.7.

2.2.5 Well and Piezometer Abandonment

Well abandonment for any well at the site will be conducted in accordance with 15A NCAC 2C, Part .0113 (a) (2) of the Well Construction Standards. Abandonment will be accomplished by disinfecting the well 24 hours prior to injecting a cement grout slurry from the bottom of the well to the top by means of a tremie pipe. Any casing installed in the boring will be left in place with the top cut level to existing grade and a flush mount cover installed over the abandoned well.

2.2.6 Dedicated Sampling Equipment

The water quality monitoring network for the City of Durham MSW landfill utilizes permanently affixed down-well and well head components that are capped after initial set-up. The dedicated monitoring system is comprised of an in-well, submersible bladder pump, air supply tubing and sample discharge tubing. An above-ground, portable compressor (or a compressed gas supply) and a portable controller are used to regulate of flow rates and volumes. The pump and all tubing housed within the well should be composed of polyethylene, Teflon or stainless steel components. This includes seals inside the pump, the pump body, and fittings used to connect tubing to the pump. The pump consists of a bladder and an exterior casing or pump body that surrounds the bladder and two (2) check valves. Specifications for the dedicated sampling systems are provided in **Appendix III**.

The purpose of low-flow purging and sampling is the recovery of representative samples of the water in the formation adjacent to the well screen. Stagnant water above the screen and below will not usually be purged or sampled. To ensure representative sampling, the intake of the pump should be positioned at the midpoint of the screened interval. The dedicated bladder pump will be used for both purging and sampling, position the pump midway between the measured water level and the bottom of the screen. Otherwise, position the pump or intake hose near the top of the water column. Any revisions to the dedicated monitoring systems must be approved by the DWM, Solid Waste Section before installation.

2.2.7 Surface Water Sampling

Several surface water features are located in the vicinity of the City of Durham closed MSW landfill. Currently surface water is not sampled to monitor water quality to detect a release from the landfill into the uppermost aquifer.

2.2.7.1 Surface Water Bodies

Two intermittent streams run contiguous to the property and discharge into Ellerbe Creek approximately 150 feet from the property boundary. The northern stream is the confluence of two intermittent streams that flow from storm water detention ponds, both of which are located off-site. The northern stream passes through the compliance boundary for approximately 2,000 feet. The southern stream also originates from an off-site storm water detention pond and it passes through the southern compliance boundary for a distance of approximately 1,500 feet, receiving discharge from an on-site storm water detention basin located at the southern edge of the compliance boundary. Ellerbe Creek runs along the western side the landfill.

The water quality monitoring network designed as part of the original water quality monitoring plan (MP 1994) included sampling surface water locations at the site. This included two sampling locations (upstream and downstream of the facility) along Ellerbe Creek and two sampling locations along the intermittent stream along the northern compliance boundary of the facility.

Since semi-annual monitoring began in 1995, water has been present sporadically in the northern, intermittent stream during regular sampling events (S&ME, February 2008). Intermittent stream flow greatly reduces the likelihood of collecting samples representative surface water quality. Stagnant pools that form along the stream channel after stream flow is interrupted often result in accumulation of high metals concentrations within stream bed sediments as well as high total suspended solids. Later when flow is restored to the stream, the concentrated metals and suspended solids stored in the stream bed sediments are reintroduced to stream flow and can result in false positive results. Therefore, surface water sampling at these locations has been terminated.

In the vicinity of the Durham MSW landfill, Ellerbe Creek drains north Durham and is the most impervious watershed draining into Falls Lake (ECWA, 2003). Ellerbe Creek has been channelized (deepened and straightened) several times in the past an attempt to alleviate flooding. In August 1961, a Corps of Engineering Channel improvement project was completed on Ellerbe Creek from the mouth upstream to about Bellevue Avenue. (USACE, 1978).

The water quality monitoring performed by NCDENR and City of Durham Stormwater Services concludes that Ellerbe Creek suffers from many of the same water quality problems found in urban creeks around the country. Stream water quality is considered by NCDENR as not supporting (NS) its designated uses (recreation, fishing, and wildlife propagation and survival) and Ellerbe Creek is on the state's 303(d) list of impaired

streams from its source to Falls Lake. Chemical monitoring has shown elevated levels of iron, copper, and zinc, and elevated conductivity was measured prior to sampling (NCDENR 2001). Nutrient concentrations and dissolved oxygen levels at the Fall's Lake monitoring station improved slightly from the 1998 to 2001 (NCDENR 2001). This improvement is partially attributed to improvements at the North Durham Water Reclamation Facility (NDWRF), which has a permitted flow capacity of 20 mgd. Benthic communities observed downstream of the NDWRF are slightly better than immediately upstream. This is in part due to the diluting effect NDWRF achieves by continually adding treated water to the streams' end line of Durham's urbanized areas.

2.2.7.2 Surface Water Sampling Procedures

If the need would arise to conduct surface water sampling at the facility, the following surface water sampling guidelines should apply. The following sampling procedures are referenced from "EPA Standard Operating Procedures" and "North Carolina Solid Waste Section Guidelines for Groundwater, Soil, and Surface Water Sampling" (NCDENR, April 2008).

The actual sampling point in the stream or creek will be in an area of relatively low turbulence and aeration. The sampling point will not be located at a constriction (where creek narrows), immediately upstream or downstream of a confluence with a tributary, nor immediately upstream or downstream of any significant structure in the creek that may result in turbulence. To the extent possible, a single grab sample will be taken at mid-depth, at the center of the channel, in an area that exhibits the greatest degree of cross-sectional homogeneity. Direct dipping of the sample container into the creek is the most desirable method of collection but a laboratory cleaned stainless steel, PVC or Teflon bailer, or dipper may be used. The sample container should be rinsed with the water to be sampled prior to filling the container, unless preservatives have been added. The sample container, bailer or dipper will be lowered to the desired depth in the creek and the sampling device or container removed. Care should be taken not to allow sediment or other debris to enter the sample container. If the stream flow is not deep enough to submerse the sample container in the water, a temporary depression may be created and used to collect the sample. After the sample has been collected, the sample container should be lifted from the water or the sample poured directly into the sample container (if the sample container is not used to collect the sample). The containers for volatile organic samples should be filled to the top without bubbles or headspace. The containers should be placed in protective cooler with ice for shipping. Surface water sample results should be compared to applicable North Carolina Surface Water Quality Standards.

2.2.8 Leachate/Condensate Sampling

Neither leachate nor condensate are currently sampled at the City of Durham closed MSW landfill. If the need would arise to conduct leachate/condensate sampling at the facility, the following guidelines should apply.

To the extent possible, leachate/condensate should be sampled simultaneously during the regular semi-annual sampling event. A single grab sample shall be taken at mid-depth, at the center of the water column, in an area that exhibits the greatest degree of cross-sectional homogeneity. Direct dipping of the sample container into the sump/well head is the most desirable method of collection, but a laboratory cleaned Teflon bailer or dipper may be used. The sample container should be rinsed with the water to be sampled prior to filling the container, unless preservatives have been added. The sample container, bailer or dipper shall be lowered to the desired depth in the sump/well head and the sampling device or container removed. Care should be taken not to allow sediment or other debris to enter the sample container. If the liquid level is not deep enough to submerse the sample container in the water, a temporary depression may be created and used to collect the sample.

After the sample has been collected, the sample container should be lifted from the water or the sample poured directly into the sample container minimizing aeration and turbulent flow during the fluid transfer (if the sample container is not used to collect the sample). The containers for volatile organic samples shall be filled to the top without bubbles or headspace. The containers should be placed in protective cooler with ice for shipping.

3.0 SAMPLING AND ANALYSIS PLAN

3.1 HEALTH AND SAFETY

A site specific Health and Safety Plan (HASP) should be developed appropriate for the sampling activities and the expected chemical constituents. This section of the WQMP is not a HASP, but is intended to provide minimum guidelines to protect the sample collector from potential exposure to sample constituents, minimize accidental contamination of samples by the collector, and preserve accurate tare weights on preweighed sample containers. Sampling personnel should implement all local, state, and federal requirements relating to health and safety and should follow all local, state and federal requirements pertaining to the storage and disposal of any hazardous or investigation derived wastes.

Protective gloves should be worn when conducting all sampling activities.

- Do not let gloves come into contact with the sample or with the interior or lip of the sample container. Use clean, new, unpowdered and disposable gloves. Various types of gloves may be used as long as the construction materials do not contaminate the sample or if internal safety protocols require greater protection.
- Note that certain materials that may potentially be present in sample media which can pass through certain glove types and be absorbed in the skin. Sampling personnel should choose gloves with adequate manual dexterity and the proper permeability for the circumstances under which they will be used. Powdered gloves are not recommended unless it can be demonstrated that the powder does not interfere with the sample analysis.
- Change gloves after preliminary activities, after collecting all the samples at a single sampling point, if torn or used to handle extremely dirty or highly contaminated surfaces. Properly dispose of all used gloves as investigation derived wastes.

Properly manage all investigative derived waste (IDW).

- To prevent contamination into previously uncontaminated areas, IDW should be properly managed. This includes all water, soil, drilling mud, decontamination wastes, discarded personal protective equipment (PPE), etc. from site investigations, exploratory borings, piezometer and monitoring well installation, refurbishment, abandonment, and other investigative activities. Manage all IDW that is determined to be RCRA-regulated hazardous waste according to the local, state and federal requirements.
- Properly dispose of IDW that is not a RCRA-regulated hazardous waste but is contaminated above the Department's Soil Cleanup Target Levels or the state standards and/or minimum criteria for ground water quality. If the drill cuttings/mud or purged well water is contaminated with hazardous waste, the

DWM, Hazardous Waste Section (919-508-8400) should be consulted for disposal options. Containers holding IDW should be maintained in good condition. Containers should be periodically inspected for damage and to ensure that all required labeling (DOT, RCRA, etc.) is clearly visible.

3.2 SAMPLE LOCATIONS

The groundwater monitoring system consists of seven (7) groundwater monitor wells. The downgradient monitoring network (i.e., compliance wells) will include six groundwater monitor wells (MW-2, MW-5, MW-11, MW-12, MW-13 and MW-14). The up-gradient (i.e. background) water quality will be monitored in one well (MW-9R). All monitor wells are or will be installed in the upper-most aquifer. In addition to the seven water quality monitoring wells, nine additional wells/piezometers will be available for water level measurements. The locations of the monitor wells and piezometers which make up the water quality monitoring network are depicted on **Figure 2**.

3.3 SAMPLE FREQUENCY

The routine monitoring frequency for the sample locations identified for water quality monitoring will be on a semi-annual basis for 30 years post-closure. For each year, one sampling event will be in the spring and the second in the fall, approximately six months apart.

3.4 SAMPLING PROCEDURES

Development, purging and sampling equipment are selected so that all materials are compatible with the sample parameters and comply with state and federal regulatory requirements for sampling. Positive-gas-displacement, pneumatic bladder pumps are or will be installed in each monitoring well as dedicated purging and sampling systems.

As previously described, surface water samples are not currently conducted at the City of Durham's Closed MSWLF. If the need would arise to conduct surface water sampling at the facility, surface water sampling should also follow these guidelines. In addition, surface water samples (if necessary) shall be collected in decontaminated open top stainless steel containers or collected directly into laboratory supplied sample bottles.

In the event that non-dedicated equipment is used (i.e., reusable water level meters or development pumps), purging and sampling equipment will be cleaned between wells in accordance with standard EPA approved cleaning procedures for field equipment.

Sampling activities for wells will consist of the following steps:

- Equipment decontamination (water level meter)
- Initial well inspection
- Groundwater level measurements
- Well purging
- Field measurements
- Sample withdrawal

Sampling activities for surface water (if necessary) will consist of the following steps:

- Equipment Decontamination (where applicable)
- Sample collection
- Field measurements

These activities are listed in the order in which they will be conducted. The first activity for the wells will be to measure the groundwater levels and evacuate the wells, as described in Section 3.4.4. All water levels will be measured and wells evacuated prior to collecting the water quality samples. Due to the number of wells to be sampled, it may require two days to sample all the wells. In this event, only the wells that will be sampled that day will be evacuated; however, water levels for all of the wells will be obtained the same day.

After the wells have been evacuated, samples will be collected as described in Section 3.4.6. Sample collection will start with the first well that was evacuated and will continue in order of evacuation. The evacuation and sampling order will be conducted from the least contaminated well to the most contaminated well based on historical laboratory results.

3.4.1 Equipment Decontamination

Sampling equipment decontamination will not be required for wells with dedicated bladder pumps installed; however, for any wells sampled with a non-disposable bailer, the equipment decontamination procedure will consist of the following steps:

- Phosphate-free soap wash
- Deionized water or distilled water rinse
- Isopropyl alcohol rinse
- Deionized water or distilled water rinse
- Air dry
- For storage, wrap equipment in aluminum foil (shiny side out)

The water level indicator will be decontaminated in the field between uses at each well. Decontamination for the water level indicator will consist of the following steps:

- Phosphate-free soap wash.
- Deionized water or distilled water rinse.
- Air dry.

3.4.2 Initial Inspection

The sampling area around the wellhead should be prepared and an initial inspection of the well should be conducted prior to sampling. Special effort should be taken to prevent cross contamination or environmental contamination. Fuel-powered equipment, and any other support equipment which might impact sample quality should be placed away from sampling activities (e.g., purging, sampling, decontamination) in the downwind direction.

1. Remove the well cover and remove all standing water around the top of the well casing (manhole) before opening the well.
2. Inspect the exterior protective casing of the monitoring well for damage. Document the results of the inspection if there is a problem.
3. Place a protective covering around the well head. Replace the covering if it becomes soiled or ripped during sampling.
4. Inspect the well lock and determine whether the cap fits tightly. Replace the cap if necessary.

Observations, including site conditions, personnel, equipment, etc. should be recorded in the field logbook, or sample data collection form, and repairs should be made as necessary to maintain integrity of the well and the dedicated sampling equipment.

3.4.3 Groundwater Level Measurements

Groundwater levels will be measured in all monitoring wells during each semi-annual groundwater monitoring event, before the monitoring wells are purged. An electronic water level indicator will be used to measure depth to groundwater. The water level meter will be decontaminated between well measurements in accordance with Section 3.3.1. The water level indicator will be capable of accurately measuring depth to groundwater to the nearest 0.01 foot. All measurements will be recorded to the nearest 0.01 foot. The water level will be measured from the top of the PVC well casing. After the measurement is made, the water level probe and lead will be cleaned with a detergent and potable water solution, and rinsed with clean deionized or HPLC water.

Total well depth measurements (bottom of well) have been taken at each of the existing monitor wells. Total well measurements should not be taken during sampling events at monitor wells equipped with dedicated bladder pumps, or other low flow sampling equipment. Attempts to collect total depth measurements at wells with dedicated sampling equipment may damage the sampling equipment, wedge the measurement tools, or unnecessarily agitate water inside the well.

If a well is to be sampled, which is not equipped with dedicated sampling equipment, total depth measurements should be taken using decontaminated sampling equipment to calculate the volume of water in the well as described in Section 3.4.4.

3.4.4 Well Evacuation

3.4.4.1 Dedicated Sampling Equipment

Well evacuation and sampling at the City of Durham closed MSW landfill will be accomplished by low flow sampling using dedicated, submersible bladder pumps as described in Section 2.2.6 in conjunction with a flow through cell and water quality analyzer to continually measure field parameters. Specifications for the dedicated sampling system are also provided in **Appendix III**.

The low flow sampling technique is most representative of the water in the formation adjacent to the well screen when the pump discharge does not drawdown the water level within a well. Water levels should be measured during well purging to determine drawdown of water within the well. The pumping rate should be adjusted in an attempt to match the natural groundwater flow velocity to reduce or negate drawdown in the well. If water levels are drawn down, the stagnant water portion of the well can become mixed. If this occurs, a modified low flow philosophy should be employed.

Water should be purged from the screened interval of the well at a low flow rate ≤0.1 liter/minute. If large volumes of groundwater are needed for analyses, sampling time can be increased while pumping at the low flow rates, or if well yield is adequate, the flow rate may be increased up to ≤1 liter/min.

Representative Sample Volumes - When purging a well that has the pump intake within a fully submerged well screen the, and drawdown of water within the well does not cause mixing of the stagnant water portion of the well, the following volumes will removed:

- A minimum of one (1) volume of the pump, associated tubing and flow cell (if used) prior to collecting measurements of the field parameters.
- Field parameter measurements should be taken no sooner than two (2) to three (3) minutes apart.
- At least three (3) volumes of the pump, associated tubing and flow cell (if used) should be purged prior to collecting a sample.

Modified Low Flow Sample Volumes - If water levels are drawn down, and it is suspected that the stagnant water portion of the well has become mixed with representative samples from the natural formation, the following well volumes will be removed:

- A minimum of one (1) equivalent well volume is removed prior to measuring the indicator parameters.

- Field parameter measurements should be taken no sooner than two (2) to three (3) minutes apart.

Indicator parameters are recorded until stabilization is achieved (Section 3.4.5) and samples are collected (Section 3.4.6).

3.4.4.2 Portable Sampling Equipment

The following technique will be employed when samples are collected from a groundwater monitor well which is not equipped with dedicated, low flow sampling equipment.

Water level measurements will be performed to determine the groundwater elevations and to calculate the volume of standing water in the well. All depth and water-level measurements will be referenced to the top of the well casing (inner PVC casing) and recorded to the nearest one-hundredth of a foot. Total well depth and water level measurements will be made with an electronic measuring device graduated in feet to the nearest ±0.01 of an inch. The depth and water level are used to determine that the well has not filled with silt and to calculate the volume of standing well water. The volume of well water (in gallons) is calculated using the following equation:

$$\mathbf{V = h \times \pi r^2 \times (7.48052\ gal/ft^3)}$$

where V = volume of standing water (gallons)
h = height of standing water (feet) = casing depth - water level
r = radius of well casing (feet)

The well depth, water level measurement, and calculated well volume will be recorded in a dedicated field book. After the water level measurements are made, a minimum of three (3) well casing volumes of groundwater will be purged from the wells. If the well is purged dry before the three casing volumes are removed, the well will be allowed to recover to within 90 percent of its original level within 24 hours before sampling without additional bailing.

3.4.5 Water Quality Field Measurements

A multi-parameter water quality monitoring instrument will be used to measure field indicator parameters for establishing representative groundwater. These instruments should be calibrated with reference standards prior to and after each sampling day. Calibration results will be recorded in the field book or sample data collection form.

Field measurements of chemical parameters will be taken to indicate when purging is complete and sampling may begin. The measurements may be made periodically in accordance with the sample volumes indicated in Section 3.4.4.1, or preferably on a continuous basis using a multi-parameter probe installed in a flow cell connected to the

outlet of the well pump. The static water in the pump and delivery tubing are removed, then pumping and monitoring continues until the chemical parameters have stabilized.

The following criteria define stabilization:

Temperature: ± 0.2° C
pH: ± 0.2 Standard pH Units
Conductivity: ± 5% of prior reading
Dissolved Oxygen: ± 10% of prior reading or ± 0.2 mg/L, whichever is greater
Turbidity: ± 10% prior reading or ± 10 NTUs, whichever is greater

Samples should be collected immediately after purging is complete. The time period between completing the purge and sampling cannot exceed six hours. If sample collection does not occur within one hour of purging completion, re-measure the five field parameters: temperature, pH, specific conductance, dissolved oxygen and turbidity, just prior to collecting the sample. If the measured values are not within 10 percent of the previous measurements, re-purge the well. The exception is wells which have been purged dry.

The field equipment should be properly calibrated prior to field use, with the calibration checked in the field at each sample location. Field adjustment to the equipment should be made as necessary and recorded in the field log. The principal field equipment will be a multi-parameter flow cell which measures pH, conductivity, temperature, dissolved oxygen, and turbidity, and a water level indicator. Calibration logs for the field equipment will be maintained by the sampling staff and provided to the DWM on request. Appropriate calibration checks in the field will be recorded on the field logs and submitted with the data analysis.

3.4.6 Sample Collection

3.4.6.1 Groundwater

Once purging is complete, sampling may begin. Sampling personnel will wear clean, disposable, non-powdered nitrile gloves during sample collection for each well. Unless field conditions justify other sampling regimens, samples will be collected in the following order:

1. Volatile Organics and Volatile Inorganics
2. Extractable Organics [semi-volatile organics (SVOCs), organochlorine pesticides and PCBs], Petroleum Hydrocarbons, Aggregate Organics and Oil and Grease
3. Total Metals
4. Inorganic Nonmetallics, Physical and Aggregate Properties
5. Biologicals and Microbiologicals

If groundwater samples for metal analysis have a turbidity ≤ 10 NTU, the sample is collected and preserved. If turbidity is > 10 NTU, an additional sample may be collected

for dissolved metals to be run separately by the laboratory if a metal is detected above groundwater protection standards. Samples collected for dissolved phase metals analysis will be field filtered. The results of the dissolved phase analysis may indicate the occurrence of the suspect metal is a result of high turbidity within the unfiltered sample.

Samples collected for volatile organics analysis will be poured slowly into glass 40-ml VOC containers fitted with Teflon caps. The containers will be filled to the top to eliminate headspace or air bubbles.
Samples collected for metals analysis will be collected in polyethylene containers. The containers are most often plastic bottles containing a small volume of nitric acid preservative.

Samples collected for SVOC analysis will be collected following collection of the inorganics. Generally the SVOCs are collected in unpreserved one liter amber bottles. These bottles should be rinsed prior to filling.

3.4.6.2 Surface Water

The following sampling procedures are referenced from "EPA Standard Operating Procedures" and *North Carolina Water Quality Monitoring Guidance Document for Solid Waste Facilities* (NCDENR, 1987) and *Solid Waste Section Guidelines for Groundwater, Soil, and Surface Water Sampling* (NCDENR, April 2008). As previously described, surface water samples are not currently conducted at the City of Durham's Closed MSWLF. If the need would arise to conduct surface water sampling at the facility, the following surface water sampling guidelines should apply.

The actual sampling point in the stream or creek will be in an area of minimal turbulence and aeration. The sampling point will not be located at a constriction (where creek narrows), immediately upstream or downstream of a confluence with a tributary, nor immediately upstream or downstream of any significant structure in the creek that may result in turbulence. To the extent possible, a single grab sample will be taken at mid-depth, at the center of the channel, in an area that exhibits the greatest degree of cross-sectional homogeneity. Direct dipping of the sample container into the creek is the most desirable method of collection but a laboratory cleaned stainless steel, PVC or Teflon bailer, or dipper may be used. The sample container should be rinsed with the water to be sampled prior to filling the container, unless preservatives have been added. The sample container, bailer or dipper will be lowered to the desired depth in the creek and the sampling device or container removed. Care should be taken not to allow sediment or other debris to enter the sample container. If the stream flow is not deep enough to submerse the sample container in the water, a temporary depression may be created and used to collect the sample. After the sample has been collected, the sample container should be lifted from the water or the sample poured directly into the sample container minimizing aeration and turbulent flow during the fluid transfer (if the sample container is not used to collect the sample). The containers for volatile organic samples will be filled to the top without bubbles or headspace. The containers should be placed in protective cooler with ice for shipping.

3.4.7 Field Reporting Requirements

The sample collector will record all pertinent information regarding the purging and sampling of monitoring wells or surface water samples in a field logbook or sample collection data form. The field data will be recorded and retained in the operating record files. The data will also be submitted to the appropriate State agencies, upon request. The information will include the following:

- Identification of well
- Well depth
- Static water level depth and measurement technique
- Presence of immiscible layers and detection method
- Well yield - high or low
- Purge volume or pumping rate
- Sample identification numbers
- Well evacuation procedure/equipment
- Sample withdrawal procedure/equipment
- Date and time of collection
- Types of sample containers used
- Identification of replicates or blind samples
- Preservative(s) used
- Parameters requested for analysis
- Field analysis data and methods
- Sample distribution and transporter
- Field observations on sampling event
- Name of collector(s)
- Climatic conditions including estimate of air temperature

3.5 SAMPLE STORAGE AND TRANSPORT

3.5.1 Sample Containers and Preservative

All sample containers supplied for the collection of groundwater samples by the laboratory are new, pre-cleaned as approved by EPA procedures appropriate for the parameters of interest. Sample containers are kept closed until used. The laboratory performing the groundwater analysis will supply all necessary coolers, pre-cleaned containers, trip blanks, chemical preservatives, labels, custody seals, chain-of-custody and shipping forms. Adequate instructions to the laboratory will be given in advance of each monitoring event. Details concerning any changes to the monitoring plan and/or procedures will be given to the laboratory in writing prior to the field sampling personnel arriving on the site. A specific contact person will be established at both the facility and contract laboratory for communication between the two parties. Sample containers need to be constructed of a material compatible and non-reactive with the material it is to contain. As noted above, the contract laboratory performing the analysis

will supply all the required containers. A complete set of new or pre-cleaned and pre-labeled sample bottles will be removed from the cooler, and a groundwater sample from a laboratory pre-cleaned or disposable, stainless steel, PVC, or Teflon® bailer or tubing from a dedicated well pump will be poured into a fresh container. Preservatives will be added as necessary (in accordance with EPA Methods SW- 846) to the sample bottles either by the laboratory or in the field immediately prior to sampling. One trip blank prepared by the laboratory will be analyzed for each sampling event.

3.5.2 Sample Labeling

Sample containers are labeled and organized prior to field activities as part of the pre-sampling staging process. As samples are actually collected, the sampling personnel write the following information directly on the label:

1. sample identification,
2. sampling date and time,
3. initials of sample collector.
4. analysis requested
5. preservative(s), if any
6. project/site name, and
7. any other pertinent information for sample identification.

This information is also recorded in the field book and on the chain of custody (COC) record.

3.5.4 Chain-Of-Custody Record

The chain of custody (COC) program allows for tracking the possession and handling of individual samples from the time of field collection through laboratory analysis and report preparation. Samples are pre-logged prior to sample collection. This process assigns a unique tracking number for each sample and generates corresponding labels.

The COC record accompanies the sample(s), traces sample possession from time of collection to delivery to the laboratory(ies) and clearly identifies which sample containers have been designated for each requested parameter. The record includes the following types of information:

- Sample identification number
- Signature of collector
- Date and time of collection
- Sample type (e.g., groundwater, immiscible layer)
- Identification of well
- Number of containers
- Parameters requested for analysis

- Preservative used
- Signature of persons involved in the chain of possession
- Inclusive dates of possession

3.5.5 Sample Custody, Shipment and Laboratory Receipt

For the purpose of these procedures, a sample is considered in custody if it is:

- In actual possession of the responsible person;
- In view, after being in physical possession;
- Locked so that no one can tamper with it, after having been in physical custody; or in a secured area, restricted to authorized personnel.

All samples are maintained in the custody of the sampling crew during the sampling event. At the end of each sampling day and prior to the transfer of the samples off-site, chain-of-custody entries are completed on the COC for all samples. Upon transfer of custody, the chain-of-custody form is signed (relinquished) by a sampling crew member, including the date and time. All chain-of-custody forms received by the laboratory(s) are signed and dated (accepted by) by the respective Supervising Scientist(s) or the laboratory sample custodian immediately following receipt by the laboratory. The analysts at the laboratory(s) maintain a sample-tracking record that will follow each sample through all stages of laboratory processing. The sample tracking records show the date of sample extraction or preparation, and analysis. These records are used to determine compliance with holding time limits during lab audits and data validation.

3.6 QUALITY CONTROL

3.6.1 Contamination Prevention

Personnel should take special effort to prevent cross contamination or environmental contamination when collecting samples.

- If possible, collect samples from the least contaminated sampling location (or background sampling location, if applicable) to the most contaminated sampling location.
- Collect the ambient or background samples first, and store them in separate ice chests or separate shipping containers within the same ice chest.
- Collect samples in flowing water at designated locations from upstream to downstream.

Do not store or ship highly contaminated samples or samples suspect of containing high concentrations of contaminants in the same ice chest or shipping containers with other environmental samples.

- Isolate sample containers by sealing them in separate, untreated plastic bags immediately after collecting, preserving, labeling, etc.
- Use a clean, untreated plastic bag to line the ice chest or shipping container.

All sampling equipment should be thoroughly decontaminated and transported in a manner that does not allow it to become contaminated. Arrangements should be made ahead of time to decontaminate any sampling or measuring equipment that will be reused when taking samples from more than one well. Field decontamination of sampling equipment will be necessary before sampling each well to minimize the risk of cross contamination. Decontamination procedures should be included in reports as necessary. Certified pre-cleaned sampling equipment and containers may be used. When collecting aqueous samples, rinse the sample collection equipment with a portion of the sample water before taking the actual sample. Sample containers do not need to be rinsed. In the case of petroleum hydrocarbons, oil and grease, or containers with pre-measured preservatives, the sample containers cannot be rinsed.

Place all fuel-powered equipment away from, and downwind of, any site activities (e.g., purging, sampling, decontamination).

- If field conditions preclude such placement, place the fuel source(s) as far away as possible from the sampling activities and describe the conditions in the field notes.
- Handle fuel (i.e., filling vehicles and equipment) prior to the sampling day. If such activities must be performed during sampling, the personnel must wear disposable gloves.
- Dispense all fuels downwind. Dispose of gloves well away from the sampling activities.

3.6.2 Quality Control Samples

Trip Blank - A trip blank will be prepared for each sample event to evaluate possible sample contamination that may occur during transport/shipping to and from the site. Trip blanks will be prepared by the laboratory and will accompany the sample containers from the laboratory to the field and back to the laboratory. The trip blank will be labeled and remain unopened throughout the duration of the field activities and subsequent shipment of the filled containers back to the laboratory. Trip blanks will be analyzed for each parameter of the record samples, depending on the sample analysis requirements.

Equipment Blank - To evaluate the effectiveness of the decontamination process, an equipment rinse blank will be prepared during each sampling event by passing laboratory-supplied deionized water through the same sampling equipment used for collection of the compliance samples into a second empty laboratory-supplied sample container. In the case where a bailer or dedicated pump is used to collect the samples, the equipment rinse blank will be prepared by pouring laboratory-supplied deionized water directly into the sampling equipment and then transferring the water directly into the laboratory-supplied containers.

One equipment blank will be collected for each sampling event. The equipment blank will be analyzed for the each parameter of the record samples.

Field Duplicate - One duplicate sample will be analyzed for each parameter of the record samples for each sampling event. At least one duplicate sample will be collected during each sampling event. The sampling personnel will select a sampling location at random in the field and the location will be identified in the logbook. When the selected location is sampled, an additional set of sample containers will be prepared and labeled with the sample location listed as "duplicate". The sampling date will be recorded on the container, but not the sample identification information or sampling time. The time of duplicate sample collection will be noted in the field book. Sample containers for the record and duplicate sample will be filled at the same time, alternately, to maximize the reproducibility of analyses between the record and duplicate sample containers.

The filled sample bottles will be labeled and securely placed into a pre-cleaned cooler with wet ice and a chain-of-custody form completed and placed with the samples prior to shipping to a laboratory for analysis. Duplicate samples are only labeled as "Duplicate" with the date sampled. No sample time or location designation will be noted on the duplicate sample containers. Upon completion of sampling, the well will be capped and secured.

3.6.3 Sample Storage and Transport

Sample labels and seals will be attached to each sample bottle. The sample labels will be used to identify the sample location, date and time of collection, sample collector, parameters to be analyzed, and type of preservation. A sample seal will be placed on each bottle or a seal will be placed on the shipping container to insure the samples are not disturbed during transportation.

3.6.4 Chain-of-Custody and Analysis Request Forms

A chain-of-custody record will be kept for each sample, and will be filled out at the time of sample collection. Information contained on a chain-of-custody record generally match the requirements of EPA's RCRA Technical Enforcement Guidance Document (TEGD). A sample analysis request sheet will also be filled out at the time of sample collection. Information for the sample request sheet can be incorporated in the chain-of-custody record.

3.6.3 Laboratory Activities

A laboratory logbook(s) will be maintained by the laboratory for tracking the storage, processing and analysis of each sample. The laboratory logbook will contain information on sample storage location; preparation techniques, such as digestion or extraction

methods; instrumentation used for sample analysis; results of routine QC samples for each batch of samples analyzed; and dates, times, and personnel performing each processing and analysis step.

In addition to a laboratory log book and chain-of-custody, laboratory measures used to ensure the acceptability of analytical results include the use of calibration blanks, calibration verification standards, sample spikes, surrogate spikes, and laboratory replicates. Results of analyses on these quality control measures will be reported with the results of the record sample analyses. The quality control samples (calibration blanks and control standards, sample spikes, surrogate spikes, and laboratory replicates) will be analyzed at a minimum frequency of one per 20 samples, or one per analytical batch, whichever frequency is greater.

4.0 DATA EVALUATION AND REPORTING

As referenced in the North Carolina Solid Waste Management Rules (15A NCAC 13B, Section .0600), solid waste management facilities are required to provide such groundwater monitoring capability as the NCDENR determines to be necessary to detect the effects of the facility on the groundwater in the area. Upon completion of field sampling activities and receipt of laboratory analysis, data should be compiled and reviewed for quality and accuracy with the objective of identifying if a release has occurred from the landfill into the uppermost aquifer.

4.1 VALIDATION OF FIELD DATA PACKAGE

The field data package includes all of the field records and measurements developed by the sampling team personnel. The field data package validation procedure consists of:

- A review of field data contained in the field logbook or sample data collection forms for completeness.
- Verification that equipment blanks, field blanks, and trip blanks were properly prepared, identified, and analyzed.
- A check of the field sampling calibration forms for equipment calibration and instrument condition.
- A review of the Chain-Of-Custody Record for proper completion, signatures of field personnel and the laboratory sample custodian, and dates, and for verification that the correct analyses were specified.

4.2 STATISTICAL ANALYSIS

The statistical methods used to analyze the data will be those outlined in EPA's Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, Addendum to Interim

Final Guidance (July 1992) which has been adopted by the North Carolina Department of Environment and Natural Resources Solid Waste Management Guidelines 15A NCAC 13B.1632. The statistical method chosen to evaluate ground-water monitoring data will comply with the standards outlined in 15A NCAC 13B Part .1632

If a new monitor well is added to the water quality monitoring network, a statistical analysis will be applied after the completion of four sampling events for the newly established groundwater quality monitoring network. If through the statistical analysis it is determined there is a statistically significant increase over background values at each water quality monitor well, a report detailing the findings will be submitted to the NCDENR - Solid Waste Section within 14 days of completing the statistical Analysis.

4.3 DETECTION MONITORING

Detection monitoring is performed to determine if a statistically significant increase over background values has occurred in any of the downgradient compliance monitoring points. The compliance monitoring data under the Detection Monitoring Program will be analyzed statistically to determine if a release has occurred. Prior to determining the appropriate statistical method to use, the distribution of the compliance data set will be evaluated. The appropriate statistical method will be chosen based on the distribution of the compliance data set. All analytical reports will be completed with referenced analytical methodologies, QA/QC documentation, field logs, analysis request forms, chain-of-custody forms, and parameter concentrations. A complete list of all Appendix I Constituents is included in **Table 5**.

The groundwater analytical results will be evaluated to determine if statistically significant evidence of contamination exists between the "background" (up-gradient) well samples and the "compliance" (down-gradient) well samples. Statistics will be applied on well locations that have four or more data points to analyze. One or more of the following statistical tests will be used:

- Shapiro-Wilk Normality Tests
- Shapiro-Francia Normality Tests
- Parametric analysis of variance using comparison of mean values.
- Parametric analysis of variance using comparison of median values.
- Parametric or Non-parametric Tolerance Intervals.
- Parametric or Non-parametric Prediction Intervals.
- Control chart approach.
- An alternative chosen by the operator and acceptable to the Division.

A determination will be made whether or not there is a statistically significant increase over background values for each analytical parameter. Within 14 days of completing the statistical analysis for the analytical data, the operator will submit a report to the Division. The report will include field observations relating to condition of monitoring wells, field data, statistical analysis, sampling methodologies, chain-of-custody records,

QC/QA data, information on groundwater flow direction, groundwater flow rate calculations, effective porosity of formation materials (at screened interval), constituents that exceed the statistically computed Upper Limits for each well and any other pertinent information related to the sampling event.

If there is a statistically significant increase over the background levels or an exceedance of state standards for any constituent on the specific parameter suite being analyzed, the well(s) will be re-sampled within the compliance period (prior to the next routine monitoring event) to verify the water quality data. If the additional data support the conclusion of a statistical increase in compliance well(s) is verified the following will be performed:

- Report to the Division and place a notice in the operating record within 14 days of finding indicating the constituents exceeding background levels; and, either

- Demonstrate that either a source other than the landfill unit caused contamination or that an error in sampling, analysis or evaluation occurred; or

- Establish an Assessment Monitoring Program meeting the requirements of Rule 15A NCAC, 13B Part .1634 of within 90 days that includes sampling of all detection monitoring wells for Appendix II (EPA, Subtitle D Regulations) constituents.

4.4 ASSESSMENT MONITORING

If a statistically significant increase in the compliance well(s) is confirmed, within 90 days following the confirmation of a statistically significant increase an Assessment Monitoring Program will be implemented. The assessment monitoring will be designed to meet the requirements of 15A NCAC - 13B Part .1633. The program will be designed to assess the rate and extent of migration of leachate in the groundwater. Within 90 days after the Assessment Monitoring Program is triggered, additional groundwater samples will be collected from the compliance (down-gradient) wells and analyzed for constituents in Appendix II of 40 CFR Part 258. Following analysis of these samples, both background and compliance wells will be re-sampled and analyzed for any Appendix II constituents detected in the down-gradient wells. Four independent samples will be collected from each monitoring well and analyzed to establish a baseline for the new constituents.

The background concentration, as defined by the up-gradient wells, will be established for each of the Appendix II constituents detected from the samples. Background to compliance well concentrations will be statistically tested using the methods outlined in Section 4.2 of this document. Groundwater protection standards will also be developed for each Appendix II constituent detected in the down-gradient wells. These standards will be based on background levels in the upgradient wells as well as the established 15A NCAC 2L groundwater quality standards (2L standard) established by the State of North

Carolina. If the constituent does not have a 2L standard, or the background concentration exceeds the 2L standard, the protection standard will be based on either the background concentration or North Carolina's published Groundwater Protection Standard for the particular constituent.
If the concentrations of all Appendix II constituents are shown to be at or below background values using the approved statistical procedures for two consecutive sampling events, the owner or operator shall report this information to the division, and the division may give approval to the owner or operator to return to the Detection Monitoring Program. If the concentrations of the Appendix II constituents for the compliance wells are statistically higher than the background wells but are below the 2L standards or Groundwater Protection Standards (GPS), then assessment monitoring will continue. Sample frequency for the assessment monitoring will be semi-annual for the active life of the facility, or until the Detection Monitoring Program is reinstated, or corrective measures are required. If, as a result of the assessment monitoring, it is determined that there is a statistically significant increase in concentration for compliance wells for constituents under Appendix II on a point comparison basis compared directly to the 2L standard or Groundwater Protection Standard (GPS), NCDENR will be notified within 14 days of this finding. At this point, requirements under §.1635 will be implemented. Once the appropriate corrective measures are approved, a Corrective Action Monitoring program will be implemented per 15A NCAC 13B.1635. A complete list of all Appendix II Constituents is included in **Table 6**.

4.5 REPORT CONTENTS & SUBMISSION

A report shall be submitted to the NCDENR which will include, at a minimum, a summary table of the field and laboratory data and a cover letter describing sampling methodology and data trends will be submitted to the NCDENR-DWM within 90 days of sampling. The DWM will be notified in the event that vendor lab analyses have not been completed within this time frame. At a minimum the report shall include the following information: field observations relating to the condition of the monitoring wells, field data, laboratory data, statistical analysis, sampling methodologies, quality assurance and quality control data, information on ground-water flow direction, calculations of ground-water flow rate, for each well any constituents that exceed ground-water standards or show a statistically significant increase over background levels, and any other pertinent information related to the sampling event.

The report should also include a site topographic map depicting the configuration of the landfill pursuant to the permit description. This map should clearly show the permitted location of the landfill with respect to the entire property.

All Groundwater Monitoring Data Sheets, Field Calibration Forms, Chain-of-Custody Record, Laboratory(s) QA data, and Data Validation Checklists, not included in the report, should be kept on file and made available to NCDENR upon request.

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TABLES

Table 1
Average Hydraulic Conductivity from Rising Head Tests
City of Durham Closed Municipal Solid Waste Landfill - Permit # 32-01
S&ME Project No. 1054-07-469

Well ID	ft/sec	ft/min	ft/day	cm/sec	m/sec	m/min
MW-2	2.02E-06	1.21E-04	0.175	6.16E-05	6.16E-07	3.70E-05
MW-3R	3.19E-06	1.91E-04	0.275	9.71E-05	9.71E-07	5.83E-05
MW-4R	2.33E-06	1.40E-04	0.201	7.10E-05	7.10E-07	4.26E-05
MW-5	1.85E-06	1.11E-04	0.159	5.63E-05	5.63E-07	3.38E-05
MW-6R	1.51E-06	9.04E-05	0.130	4.59E-05	4.59E-07	2.75E-05
MW-7R	2.30E-06	1.38E-04	0.199	7.02E-05	7.02E-07	4.21E-05
MW-8	1.14E-05	6.85E-04	0.987	3.48E-04	3.48E-06	2.09E-04
MW-9R	1.54E-06	9.24E-05	0.133	4.69E-05	4.69E-07	2.82E-05

Notes:
Hydraulic conductivity tests (rising head tests) performed by S&ME in May 2008.
Slug test data analyzed using Aqtesolv modeling software using the Bouwer-Rice method for unconfined partially penetrating or fully penetrating well screens.

Table 2
Estimated Groundwater Flow Velocity
City of Durham Closed Municipal Solid Waste Landfill - Permit # 32-01
S&ME Project No. 1054-07-469

ESTIMATED GROUNDWATER FLOW RATES AT WELL LOCATIONS				
Well Location	**Groundwater Gradient**	**Hydraulic Conductivity Values (cm/sec)**	**Effective Porosity (%)**	**Estimated Velocity (ft/yr)**
MW-2	0.0420	6.16E-05	20	13.33
MW-4R	0.0227	7.10E-05	20	8.30
MW-5	0.0430	5.64E-05	20	12.49
MW-7R	0.0149	7.01E-05	20	5.38
MW-8	0.0256	3.48E-04	20	45.88
MW-9R	0.0545	4.69E-05	20	13.17

Notes:
cm/sec = centimeters per second
ft/yr = feet per year
Hydraulic conductivity testing for MW-2, MW-4R, MW-5, MW-7R, MW-8 and MW-9R was performed by S&ME, Inc. in May 2008.
Estimated flow rate not calculated for MW-6R because MW-6R has been removed from the water quality monitoring network.
Estimated flow rate not calculated for MW-3R due to lack of elevation data.

Table 3
Monitoring Well/Piezometer Construction Details
City of Durham Closed Municipal Solid Waste Landfill
S&ME Project No. 1054-07-469
Permit # 32-01

Well/Piezometer Identification	Ground Surface Elevation (ft AMSL)	TOC Elevation (ft AMSL)	Stick-up Interval (ft)	Well Depth* (ft bgs)	Well Diameter (inches)	Screened Interval** (ft bgs)
MW-2	284.91	286.54	1.63	19.62	2	9.62 - 19.62
MW-3R	--	--	2.91	17.65	2	7.65 - 17.65
MW-4R	293.23	295.63	2.40	17.39	2	7.39 - 17.39
MW-5	298.00	299.76	1.76	21.77	2	11.77 - 21.77
MW-7R	315.88	318.21	2.33	44.10	2	19.10 - 44.10
MW-8	309.60	313.10	3.50	16.52	2	9.02 - 16.52
MW-9R	358.96	361.47	2.51	22.55	2	12.55 - 22.55
MW-10	280.90	284.00	3.10	16.61	2	6.61-16.61
MW-11	TBD	TBD	TBD	TBD	2	TBD
MW-12	TBD	TBD	TBD	TBD	2	TBD
MW-13	TBD	TBD	TBD	TBD	2	TBD
MW-14	TBD	TBD	TBD	TBD	2	TBD
PZ-2R	344.06	346.56	2.50	34.59	2	24.59 - 34.59
PZ-3	346.78	350.03	3.25	42.40	2	27.40 - 42.40
PZ-4R	336.57	339.42	2.85	38.38	2	23.38 - 38.38
PZ-6	347.76	350.11	2.35	61.50	2	41.50 - 61.50

Notes:
ft AMSL = feet above mean sea level
TOC = top of well casing elevation
-- = no data available
bgs = below ground surface
TOC and Ground Surface Elevations were surveyed by Barbara H. Mulkey Engineering in January 2001.
TOC and Ground Surface Elevations surveyed for new wells P2-R, P-4R, MW-6R, MW-7R and MW-9R in 2005 by Mulkey Engineering.
TOC and Ground Surface Elevations surveyed for new well MW-10 TOC elevation surveyed by Bateman Civil Survey P.C. in September 2008
** Screened interval is approximate, based on field measurements by S&ME in May 2008.
* Depth to bottom measurements taken on June 13, 2008.
TBD = Monitor Wells 11-14 will be installed upon receipt of approval of the WQMP.

Table 4
Monitoring Well/Piezometer Locations and Elevations
City of Durham Closed Municipal Solid Waste Landfill
S&ME Project No. 1054-07-469
Permit # 32-01

Well/Piezometer ID	Northing	Easting	Ground Surface Elevation (ft AMSL)	Top-of -Casing Elevation (ft AMSL)
PZ-2R	831136.44	2043506.78	344.06	346.56
PZ-3	830581.61	2043460.99	346.78	350.03
PZ-4R	830318.99	2043456.93	336.57	339.42
PZ-6	831072.37	2043873.16	347.51	350.11
MW-2	831828.02	2042303.29	284.91	286.54
MW-3R	830508.02	2041431.79	--	--
MW-4R	829624.77	2042330.46	293.23	295.63
MW-5	832230.50	2043386.22	298.00	299.76
MW-7R	831775.12	2043783.06	315.88	318.21
MW-8	829821.92	2043599.54	310.80	313.10
MW-9R	830702.99	2043834.41	359.17	361.47
MW-10	830933.88	2041289.17	280.90	284.00
MW-11	832308.73*	2042308.98*	TBD	TBD
MW-12	831.525.51*	2041749.89*	TBD	TBD
MW-13	831136.4*	2041117.19*	TBD	TBD
MW-14	830164.16*	2041429.56*	TBD	TBD

Notes:
ft-AMSL: Feet above mean sea level
Northing/Easting Datum = NAD 83
Vertical Datum = NGVD 29 Feet AMSL
Units = US Survey Feet
TOC and Ground Surface Elevations were surveyed by Barbara H. Mulkey Engineering in January 2001.
TOC and Ground Surface Elevations surveyed for new wells P2-R, P-4R, MW-6R, MW-7R and MW-9R in 2005 by Mulkey Engineering.
TOC and Ground Surface Elevations surveyed for new well MW-10 TOC elevation surveyed by Bateman Civil Survey P.C. in September 2008
TBD = Monitor Wells 11-14 will be installed upon receipt of approval of the WQMP.
* = Northings and Eastings are approximate and will be updated upon completion of the new monitor well network.

Table 5
Constituents for Detection Monitoring (40 CFR 258, Appendix I)
City of Durham Closed Municipal Solid Waste Landfill
S&ME Project No. 1054-07-469
Permit # 32-01

Appendix I Constituent - Common name	CAS Number
Antimony	7440-36-0
Arsenic	7440-38-2
Barium	7440-39-3
Beryllium	7440-41-7
Cadmium	7440-43-9
Chromium	7440-47-3
Cobalt	7440-48-4
Copper	7440-50-8
Lead	7440-92-1
Nickel	7440-02-0
Selenium	7440-49-2
Silver	7440-22-4
Thallium	7440-28-0
Vanadium	7440-62-2
Zinc	7440-66-6
Acetone	67-64-1
Acrylonitrile	107-13-1
Benzene	71-43-2
Bromochloromethane	74-97-5
Bromodichloromethane	75-27-4
Bromoform; Tribromomethane	75-25-2
Carbon disulfide	75-15-0
Carbon tetrachloride	56-23-5
Chlorobenzene	108-90-7
Chloroethane; Ethyl chloride	75-00-3
Chloroform; Trichloromethane	67-66-3
Dibromochloromethane; Chlorodibromomethane	124-48-1
1,2-Dibromo-3-chlorpropane; DBCP	96-12-8
1,2-Dibromoethane; Ethylene dibromide; EDB	106-93-4
o-Dichlorobenzene; 1,2-Dichlorobenzene	95-50-1
p-Dichlorobenzene; 1,4-Dichlorobenzene	106-46-7
trans-1,4-Dichloro-2-butene	110-57-6
1,1-Dichloroethane; Ethylidene chloride	75-34-3
1,2-Dichloroethane; Ethlyene dichloride	107-06-2

Table 5
Constituents for Detection Monitoring (40 CFR 258, Appendix I)
City of Durham Closed Municipal Solid Waste Landfill
S&ME Project No. 1054-07-469
Permit # 32-01

Appendix I Constituent - Common name	CAS Number
1,1-Dichloroethylene; 1-1-Dichloroethene; Vinylidene chloride	75-35-4
cis-1,2-Dichloroethylene; cis-1,2-Dichloroethene	156-59-2
trans-1,2-Dichloroethylene; trans-1,2-Dichloroethene	156-60-5
1,2-Dichlorpropane; Propylene dichloride	78-87-5
cis-1,3-Dichlorpropene	10061-01-5
trans-1,3-Dichlorpropene	10061-02-6
Ethylbenzene	100-41-4
2-hexanone; Methyl butyl ketone	591-78-6
Methyl bromide; Bromomethane	74-83-9
Methyl chloride; Chloromethane	74-87-3
Methylene bromide Dibromomethane	74-95-3
Methylene chloride; Dichloromethane	75-09-2
Methyl ethyl ketone; MEK; 2-Butanone	78-93-3
Methyl iodide; Iodomethane	74-88-4
4-Methyl-2-pentanone; Methyl isobutyl isobutyl ketone	108-10-1
Styrene	100-42-5
1,1,1,2-Tetrachloroethane	630-20-6
1,1,2,2-Tetrachloroethane	79-34-5
Tetrachloroethylene; Tetracholorethene; Perchloroethylene	127-18-4
Toluene	108-88-3
1,1,1-Trochlorethane; Methylchloroform	71-55-6
1,1,2-Trichloroethane	79-00-5
Trichloroethylene; Trichlorethene	79-01-6
Trichlorofluoromethane; CFC-11	75-69-4
1,2,3-Trichloropropane	96-18-4
Vinyl acetate	108-05-4
Vinyl chloride	75-01-4
Xylenes	1330-20-7

Table 6
Constituents for Assessment Monitoring (40 CFR 258, Appendix II)
City of Durham Closed Municipal Solid Waste Landfill
S&ME Project No. 1054-07-469
Permit # 32-01

Appendix II Constituents - Common Name	CAS Number
Acenaphthene	83-32-9
Acenaphthylene	208-96-8
Acetone	67-64-1
Acetonitrile; Methyl cyanide	75-05-8
Acetophenone	98-86-2
2-Acetylaminofluorene; 2-AAF	53-96-3
Acrolein	107-02-8
Acrylonitrile	107-13-1
Aldrin	309-00-2
Allyl chloride	107-05-1
4-Aminobiphenyl	92-67-1
Anthracene	120-12-7
Antimony	7440-36-0
Arsenic	7440-38-2
Barium	7440-39-3
Benzene	71-43-2
Benzo[a]anthracene; Benzanthracene	56-55-3
Benzo[b]fluoranthene	205-99-2
Benzo[k]fluoranthene	207-08-9
Benzo[ghi]perylene	191-24-2
Benzo[a]pyrene	50-32-8
Benyl alcohol	100-51-5
Beryllium	7440-41-7
alpha-BHC	319-84-6
beta-BHC	319-85-7
delta-BHC	319-86-8
gamma-BHC; Lindane	58-89-9
Bis(2-chloroethoxy)methane	111-91-1
Bis(2-chloroethyl)ether; Dichloroethyl ether	111-44-4
Bis-(2-chlor-1-methyl) ether; 2, 2-Dichloro-	108-60-1
diisopropyl ether; DCIP	See note 6
Bis(2-ethylhexyl) phthalate	117-81-7
Bromochloromethane; Chlorobromomethane	74-97-5
Bromodichloromethane; Dibromochloromethane	75-27-4
Bromoform; Tribromomethane	75-25-2

Table 6
Constituents for Assessment Monitoring (40 CFR 258, Appendix II)
City of Durham Closed Municipal Solid Waste Landfill
S&ME Project No. 1054-07-469
Permit # 32-01

Appendix II Constituents - Common Name	CAS Number
4-Bromophenyl phenyl ether	101-55-3
Butyl benzyl phthalate; Benzyl butyl phthalate	85-68-7
Cadmium	7440-43-9
Carbon disulfide	75-15-0
Carbon tetrachloride	56-23-5
Chlordane	See NOTE 1
p-Chloroaniline	106-47-8
Chlorobenzene	108-90-7
Chlorobenzilate	510-15-6
p-Chloro-m-cresol; 4-Chloro-3-methylphenol	59-50-7
Chloroethane; Ethyl chloride	75-00-3
Chloroform; Trichloromethane	67-66-3
2-Chloronaphthalene	91-58-7
2-Chlorophenol	95-57-8
4-Chlorophenyl phenyl ether	7005-72-3
Chloroprene	126-99-8
Chromium	7440-47-3
Chrysene	218-01-9
Cobalt	218-01-9
Copper	7440-50-8
m-Cresol; 3-methylphenol	108-39-4
o-Cresol; 2-methlphenol	95-48-7
p-Cresol; 4-methylphenol	106-44-5
Cyanide	57-12-5
2,4-D; 2,4-Dichlorophenoxyacetic acid	94-75-7
4,4-DDD	72-54-8
4,4-DDE	72-55-9
4,4-DDT	50-29-3
Diallate	2303-16-4
aDibenz[a,h]anthracene	53-70-3
Dibenzofuran	132-64-9
Dibromochloromethane; Chlorodibromomethane	124-48-1
1,2-Dibromo-30chloropropane; DBCP	96-12-8
1,2-Dibromoethane; Ethylene dibromide; EDB	106-93-4
Di-n-butyl phthalate	84-74-2

Table 6
Constituents for Assessment Monitoring (40 CFR 258, Appendix II)
City of Durham Closed Municipal Solid Waste Landfill
S&ME Project No. 1054-07-469
Permit # 32-01

Appendix II Constituents - Common Name	CAS Number
o-Dichlorobenzene; 1,2-Dichlorobenzene	95-50-1
m-Dichlorobenzene; 1,3-Dichlorobenzene	541-73-1
p-Dichlorobenzene; 1,4-Dichlorobenzene	106-46-7
3,3-Dichlorobenzidine	91-94-1
trans-1,4-Dichloro-2-butene	110-57-6
Dichlorodifluoromethane; CFC 12;	75-71-8
1,1-Dichloroethane chloride	75-34-3
1,2-Dichloroethane; Ethylene dichloride	107-06-2
1,1-Dichloroethylene; 1,1-Dichloroethane;	75-35-4
Vinylidene chloride	75-35-4
cis-1,2-Dichloroethylene; cis-1,2-Dichloroethene	156-59-2
trans-1,2-Dichloroethylene trans-1,2-Dichloroethene	156-60-5
2,4-Dichlorophenol	120-83-2
2,6-Dichlorophenol	87-65-0
1,2-Dichloropropane; Propylene dichloride	78-87-5
1,3-Dichloropropane; Trimethylene dichloride	142-28-9
2,2-Dichloropropane; Isopropylidene chloride	594-20-7
1,1-Dichloropropene	563-58-6
cis-1,3-Dichloropropene	10061-01-5
trans-1,3-Dichloropropene	10061-02-6
Dieldrin	60-57-1
Diethyl phthalate	84-66-2
0,0-Diethyl 0-2-pyrazinyl phosphorothioate; thionazin	297-97-2
Dimethoate	60-51-5
p-(Dimethylamino)azobenzene	60-11-7
7,12-Dimethylbenxz[a]anthracene	57-97-6
3,3-Dimethylbenzidine	119-93-7
2,4-Dimethlphenol; m-Xylenol	105-67-9
Dimethyl phthalate	131-11-3
m-Dinitrobenzene	99-65-0
4,6-Dinitro-o-cresol 4,6-Dinitro-2-methylphenol	534-52-1
2,4-Dinitrophenol	51-28-5
2,4-Dinitrotoluene	121-14-2
2,6-Dinitrotoluene	606-20-2
Dinoseb; DNBP; 2-sec-Butyl-4,6-dinitrophenol	88-85-7

Table 6
Constituents for Assessment Monitoring (40 CFR 258, Appendix II)
City of Durham Closed Municipal Solid Waste Landfill
S&ME Project No. 1054-07-469
Permit # 32-01

Appendix II Constituents - Common Name	CAS Number
Di-n-octyl phthalate	117-84-0
Diphenylamine	122-39-4
Disulfoton	298-04-4
Endosulfan I	959-98-8
Endosulfan II	33213-65-9
Endodulfan sulfate	1031-07-8
Endrin	72-20-8
Endrin aldehyde	7421-93-4
Ethylbenzene	100-41-4
Ethyl methacrylate	97-63-2
Ethyl methanesulfonate	62-50-0
Famphur	52-85-7
Fluoranthene	206-44-0
Fluorene	86-73-7
Heptachlor	76-44-8
Heptachlor epoxide	1024-57-3
Hexachlorobenzene	118-74-1
Hexachlorobutadiene	87-68-3
Hexachlorocyclopentadiene	77-47-4
Hexachloroethane	67-72-1
Hexachloropropene	188-71-7
2-Hexanone; Methyl butyl ketone	591-78-6
Indenol(1,2,3-cd)pyrene	193-39-5
Isopbutyl alcohol	78-83-1
Isodrin	465-73-6
Isophorone	78-59-1
Isosafrole	120-58-1
Kepone	143-50-0
Lead	7440-92-1
Mercury	7434-97-6
Methacrylonitrile	126-98-7
Methapyrilene	91-80-5
Methoxychlor	72-43-5
Methyl bromide; Bromomethane	74-83-9
Methyl chloride; Chloromethane	74-87-3

Table 6
Constituents for Assessment Monitoring (40 CFR 258, Appendix II)
City of Durham Closed Municipal Solid Waste Landfill
S&ME Project No. 1054-07-469
Permit # 32-01

Appendix II Constituents - Common Name	CAS Number
3-Methylcholanthrene	56-49-5
Methyl ethyl ketone; MEK; 2-Butanone	78-93-3
Methyl iodide; lodomethane	74-88-4
Methyl methacrylate	80-62-6
Methyl methanesulfonate	66-27-3
2-Methylnaphthalene	91-57-6
Methyl parathion; Parathion methyl	298-00-0
4-Methyl-2-pentanone; Methyl isobutyl ketone	108-10-1
Methylene bromide; Dibromomethane	74-95-3
Methylene chloride; Dichloromethane	75-09-2
Naphthalene	91-20-3
1,4-Naphthoquinone	130-15-4
1-Naphthylamine	134-32-7
2-Naphthylamine	91-59-8
Nickel	7440-02-0
o-Nitroaniline; 2-Nitroaniline	88-74-4
m-Nitroaniline; 3-Nitroanile	99-09-2
p-Nitroaniline; 4-Nitroaniline	100-01-6
Nitrobenzene	98-95-3
o-Nitrophenol; 2-Nitrophenol	88-75-5
p-Nitrophenol; 4-Nitrophenol	100-02-7
N-Nitrosodi-n-butylamine	924-16-3
N-Nitrosodiethylamine	55-18-5
N-Nitrosodimethylamine	62-75-9
N-Nitrosodiphenylamine, N-Nitroso-N-Di-n- propylnitrosamine	86-30-6
N-Nitrosodipropylamine; dipropylamine;	621-64-7
N-Nitrosomethylethalamine	10595-95-6
N-Nitrosopiperidine	100-75-4
N-Nitrosopyrrolidine	930-55-2
5-Nitro-o-toluidine	99-55-8
Parathion	56-38-2
Pentachlorobenzene	608-93-5
Pentachloronitrobenzene	82-68-8
Pentachlorophenol	87-86-5
Phenacetin	62-44-2

Table 6
Constituents for Assessment Monitoring (40 CFR 258, Appendix II)
City of Durham Closed Municipal Solid Waste Landfill
S&ME Project No. 1054-07-469
Permit # 32-01

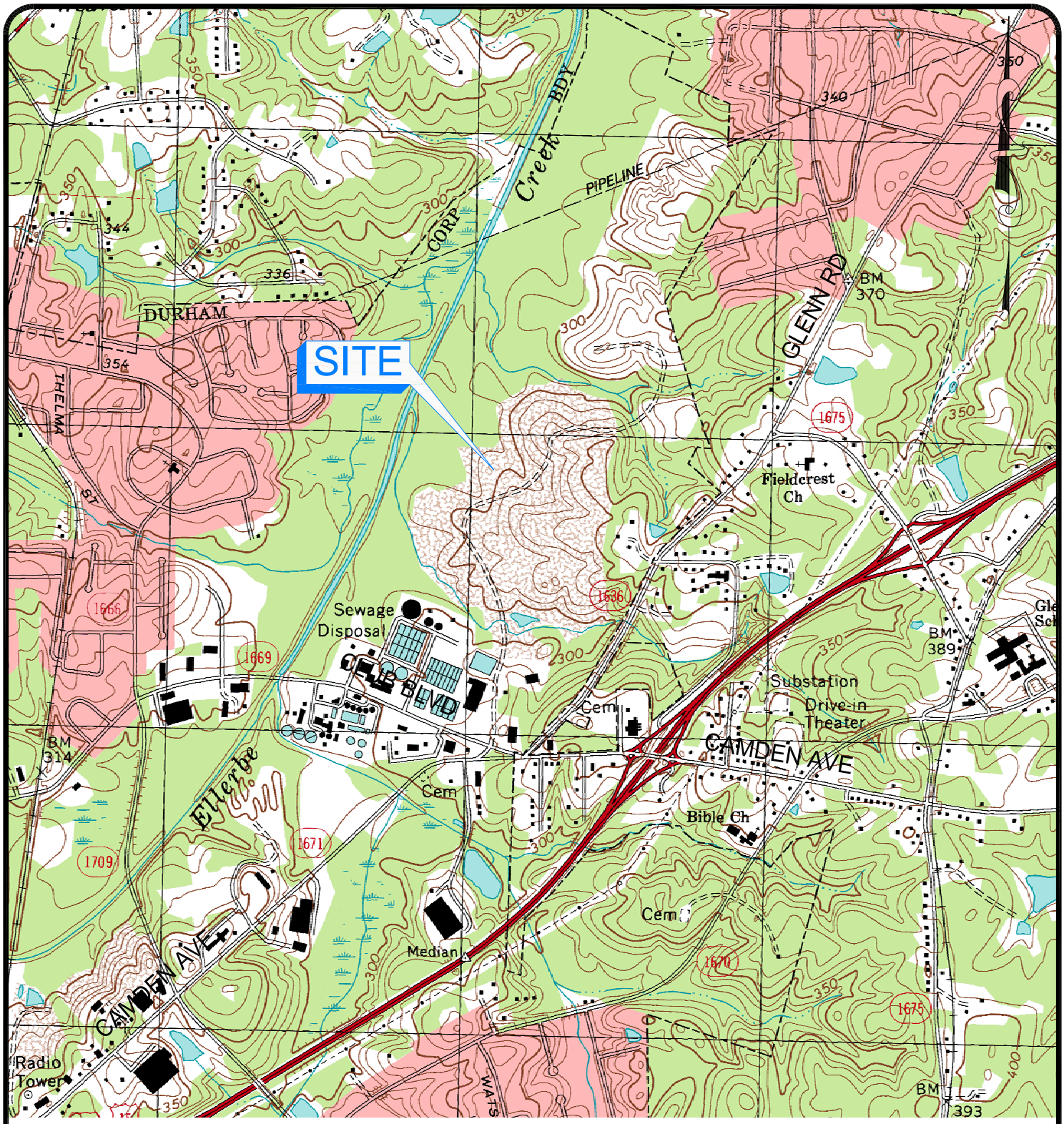
Appendix II Constituents - Common Name	CAS Number
Phenanthrene	85-01-8
Phenol	108-95-2
p-Phenylenediamine	106-50-3
Phorate	298-02-2
Polychlorinated biphenyls (PCBs); Aroclors	See NOTE 2
Pronamide	23950-58-5
Propionitrile; Ethyl cyanide	107-12-0
Pyrene	129-00-0
Safrole	94-59-7
Selenium	7440-49-2
Silver	7440-22-4
Silvex; 2,4,5-TP	93-72-1
Styrene	100-42-5
Sulfide	18496-25-8
2,4,5-T; 2,4,5-Trichlorophenoxyacetic acid	93-76-5
1,2,4,5-Tetrachlorobenzene	95-94-3
1,1,1,2-Tetrachloroethane	630-20-6
1,1,2,2-Tetrachloroethane	79-34-5
Tetrachloroethylene; Tetrachloroethene; Perchloroethylene	127-18-4
2,3,4,6-Tetrachlorophenol	58-90-2
Thallium	7440-28-0
Tin	7440-31-5
Toluene	108-88-3
o-Toluidine	95-53-4
Toxaphene	See NOTE 3
1,2,4-Trichlorobenzene	120-82-1
1,1,1-Trichloroethane; Methylchloroform	71-55-6
1,1,2-Trichloroethane	79-00-5
Trichloroethylene; Trichloroethene	79-01-6
Trichlorrofluoromethane; CFC-11	75-69-4
2,4,5-Trichlorophenol	95-95-4
2,4,6-Trichlorophenol	88-06-2
1,2,3-Trichloropropane	96-18-4
0,0,0-Triethyl phosphorothioate	126-68-1
sym-Trinitrobenzene	99-35-4

Table 6
Constituents for Assessment Monitoring (40 CFR 258, Appendix II)
City of Durham Closed Municipal Solid Waste Landfill
S&ME Project No. 1054-07-469
Permit # 32-01

Appendix II Constituents - Common Name	CAS Number
Vanadium	7440-62-2
Vinyl acetate	108-05-4
Vinyl chloride; Chloroethene	75-01-4
Xylene (total)	See NOTE 4
Zinc	7440-66-6

Notes:
1. Chlordane: This entry includes alpha-chlordane (CAS RN 5103-71-9), beta-chlordane (CAS RN 5103-74-2), gamma-chlordane (CAS RN 5566-34-7), and constituents of chlordane (CAS RN 57-74-9 and CAS RN 12789-03-6)
2. Polychlorinated biphenyls (CAS RN 1336-36-3); this category contains congener chemicals, including constituents of Aroclor-1016 (CAS RN 12674-11-2), Aroclor-1221 (CAS RN 11104-28-2), Aroclor-1232 (CAS RN 11141-16-5), Aroclor-1242 (CAS RN 53469-21-9), Aroclor-1248 (CAS RN 12672-29-6), Aroclor-1254 (CAS RN 11097-69-1), and Aroclor-1260 (CAS RN 11096-82-5)
3. Toxaphene: This entry includes congener chemicals contained in technical toxaphene (CAS RN 8001-35-2), ie, chlorinated camphene
4. Xylene (total): This entry includes o-xylene (CAS RN 96-47-6), m- xylene (CAS RN 108-38-3), p-xylene (CAS RN 106-42-3), and unspecified xylenes (dimethylbenzenes) (CAS RN 1330-20-7)

FIGURES



Note:
CONTOUR INTERVAL 5 FEET
SOURCE: NCGS DRG
NE DURHAM (O36078A7), DATED 1999

GRAPHIC SCALE

750 0 375 750 1500

(IN FEET)

A-1051

SCALE: 1" = 1500'	S&ME WWW.SMEINC.COM	VICINITY MAP CLOSED LANDFILL PERMIT #32-01 DURHAM, NORTH CAROLINA	FIGURE NO. 1of3
DATE: DEC. 2007			
DRAWN BY: BTR			
PROJECT NO: 1054-07-469			

250' COMPLIANCE BOUNDARY

SEDIMENTATION POND NO. 2

MW-11

MW-5

MW-2

MW-7R

SEDIMENTATION POND NO. 3

MW-12

ELLERBEE CREEK

MW-13

250'

MW-10

PZ-2R

PZ-6

MW-9R

PZ-3

MW-3R

PZ-4R

MW-14

MW-8

SEDIMENTATION POND NO. 1

MW-4R

250' COMPLIANCE BOUNDARY

LEGEND

MW-14 PROPOSED WATER QUALITY MONITOR WELLS

MW-10 WATER QUALITY MONITOR WELLS

PIEZOMETERS

SURFACE WATER FLOW DIRECTION

CONTOUR LINE - MAJOR (20 FT)

CONTOUR LINE - MINOR (2 FT)

APPROXIMATE LIMIT OF FILL (PER MALCOM-PIRNIE, 1998)

GRAPHIC SCALE

400 0 200 400

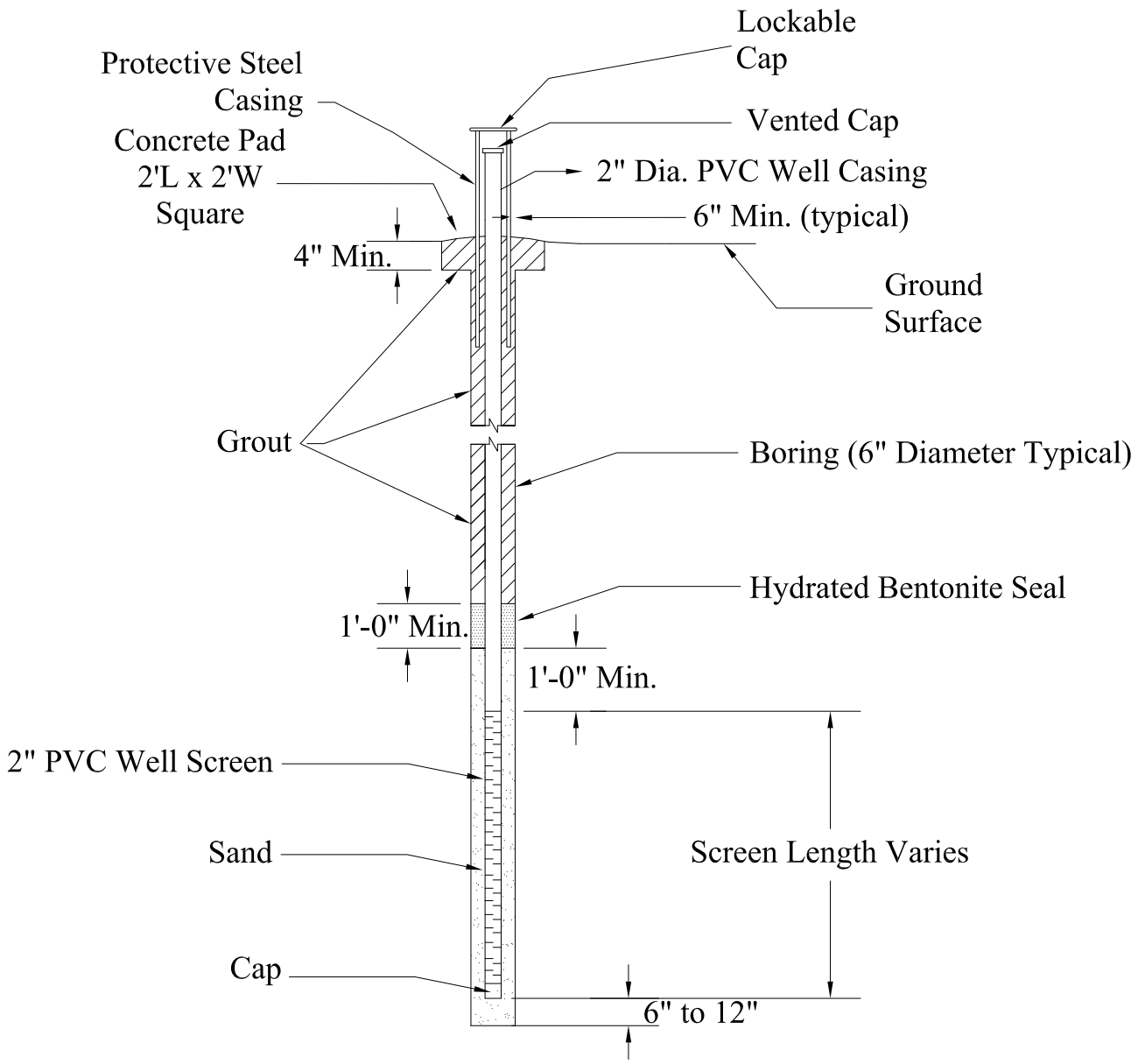
(IN FEET)

SOURCE:
CONTOURS - NCDOT LIDAR DATED APRIL 2007
BUILDINGS - DURHAM GIS DATED 1994
IMAGERY - DURHAM GIS DATED 2005

DRAWN BY:	WATER QUALITY MONITORING PLAN
CHECKED BY:	
DESIGNED BY:	CITY OF DURHAM SANITARY LANDFILL
APPROVED BY:	DURHAM, NORTH CAROLINA
PROJECT NUMBER: 1054-07-469	
SCALE: 1" = 200'	DATE: FEB. 2009
DRAWING NUMBER: D-1066	
DRAWING: 2	OF: 3

NO.	DATE	DESCRIPTION	BY

S&ME
WWW.SMEINC.COM



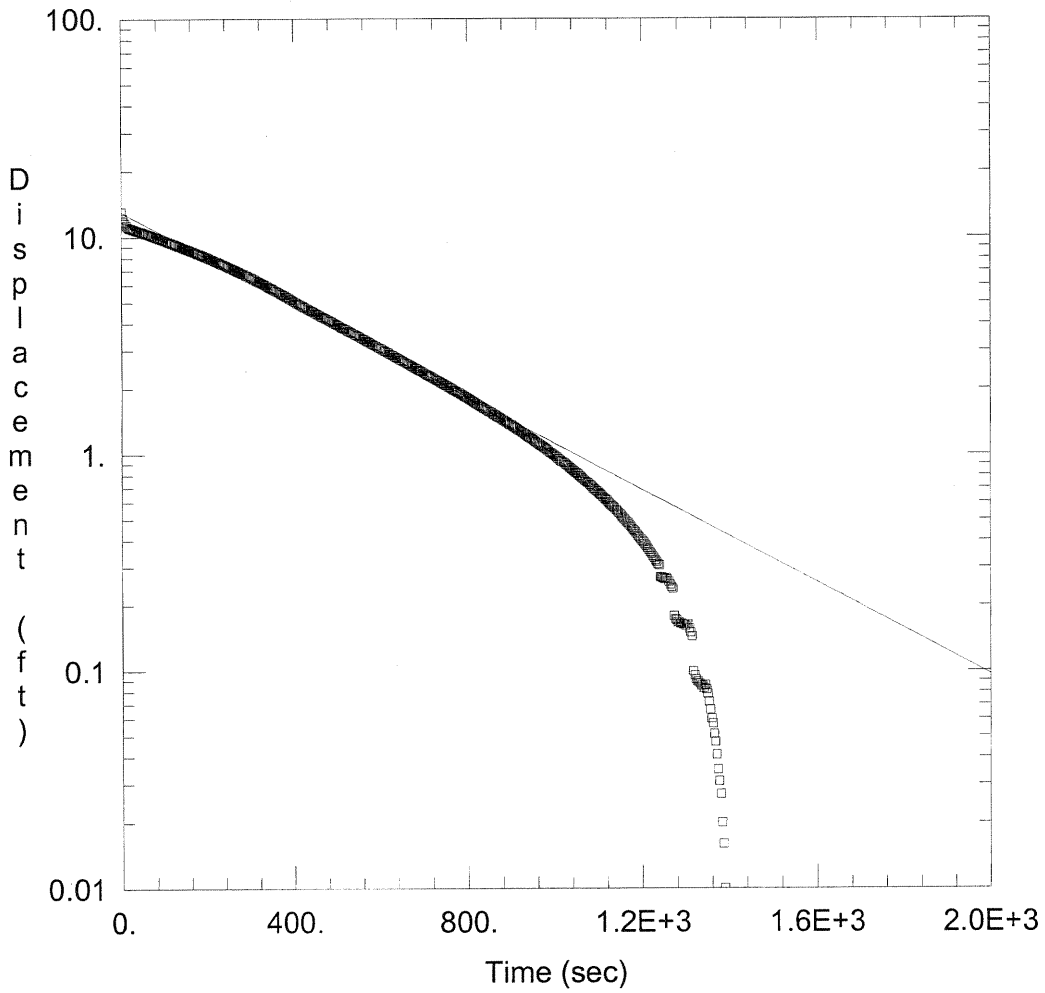
Notes:

- All well casing material will be Sch 40 PVC.
- Well screen material will be Sch 40 PVC.

SCALE: AS SHOWN	S&ME WWW.SMEINC.COM	TYPICAL MONITOR WELL DETAIL WATER QUALITY MONITORING PLAN City of Durham Closed MSWLF DURHAM, NORTH CAROLINA	FIGURE NO.
DATE: FEB. 2009			3 of 3
DRAWN BY: GHP			
PROJECT NO: 1054-07-469			

APPENDIX I

Rising Head Tests
(MW-2, MW-3R, MW-4R, MW-5, MW-7R, MW-8, MW-9R IN MAY 2008) (MW-11, MW-12, MW-13 AND MW-14 TBD)



CITY OF DURHAM MSWLF MW-2

Data Set: S:\...\MW-2.aqt
Date: 05/18/09 Time: 17:27:11

PROJECT INFORMATION

Company: City of Durham MSWLF
Client: City of Durham
Project: 1054-07-469
Location: Druham, NC
Test Well: MW-2
Test Date: April 2008

AQUIFER DATA

Saturated Thickness: 25. ft Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MW-2)

Initial Displacement: 13.05 ft
Total Well Penetration Depth: 15.95 ft
Casing Radius: 0.083 ft
Static Water Column Height: 15.95 ft
Screen Length: 10. ft
Wellbore Radius: 0.3542 ft

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

K = 6.162E-5 cm/sec
y0 = 13.01 ft

Data Set: S:\PROJECTS\2007\07-469 City of Durham MSWLF\Reports\Water Quality Monitoring Plan - Februa
Title: City of Durham MSWLF MW-2
Date: 05/18/09
Time: 17:27:55

PROJECT INFORMATION

Company: City of Durham MSWLF
Client: City of Durham
Project: 1054-07-469
Location: Druham, NC
Test Date: April 2008
Test Well: MW-2

AQUIFER DATA

Saturated Thickness: 25. ft
Anisotropy Ratio (Kz/Kr): 1.

SLUG TEST WELL DATA

Test Well: : MW-2

X Location: 0. ft
Y Location: 0. ft

Initial Displacement: 13.05 ft
Static Water Column Height: 15.95 ft
Casing Radius: 0.083 ft
Wellbore Radius: 0.3542 ft
Well Skin Radius: 0.3542 ft
Screen Length: 10. ft
Total Well Penetration Depth: 15.95 ft

No. of Observations: 465

Observation Data

Time (sec)	Displacement (ft)
3.	12.19
6.	11.74
9.	11.57
12.	11.34
15.	11.12
18.	11.02
21.	10.98
24.	10.93
27.	10.88
30.	10.82
33.	10.77
36.	10.72
39.	10.67
42.	10.62
45.	10.57
48.	10.52
51.	10.47
54.	10.42
57.	10.36
60.	10.31
63.	10.26
66.	10.21
69.	10.16
72.	10.11
75.	10.06
78.	10.01
81.	9.959
84.	9.911

Time (sec)	Displacement (ft)
87.	9.859
90.	9.81
93.	9.758
96.	9.708
99.	9.658
102.	9.608
105.	9.559
108.	9.509
111.	9.459
114.	9.409
117.	9.36
120.	9.312
123.	9.262
126.	9.211
129.	9.161
132.	9.113
135.	9.061
138.	9.012
141.	8.964
144.	8.916
147.	8.869
150.	8.819
153.	8.773
156.	8.726
159.	8.682
162.	8.635
165.	8.585
168.	8.539
171.	8.492
174.	8.444
177.	8.397
180.	8.349
183.	8.301
186.	8.254
189.	8.208
192.	8.161
195.	8.113
198.	8.067
201.	8.022
204.	7.974
207.	7.927
210.	7.881
213.	7.833
216.	7.788
219.	7.74
222.	7.693
225.	7.645
228.	7.598
231.	7.554
234.	7.506
237.	7.461
240.	7.413
243.	7.37
246.	7.322
249.	7.277
252.	7.231
255.	7.186
258.	7.14
261.	7.095
264.	7.049
267.	7.003
270.	6.958
273.	6.912
276.	6.865
279.	6.823

Time (sec)	Displacement (ft)
282.	6.776
285.	6.733
288.	6.685
291.	6.641
294.	6.596
297.	6.55
300.	6.507
303.	6.464
306.	6.418
309.	6.375
312.	6.329
315.	6.284
318.	6.238
321.	6.195
324.	6.151
327.	6.108
330.	6.064
333.	6.021
336.	5.977
339.	5.932
342.	5.891
345.	5.847
348.	5.802
351.	5.76
354.	5.717
357.	5.673
360.	5.63
363.	5.586
366.	5.545
369.	5.502
372.	5.46
375.	5.417
378.	5.376
381.	5.334
384.	5.291
387.	5.251
390.	5.21
393.	5.167
396.	5.127
399.	5.086
402.	5.045
405.	5.007
408.	4.966
411.	4.929
414.	4.892
417.	4.855
420.	4.819
423.	4.782
426.	4.745
429.	4.71
432.	4.672
435.	4.639
438.	4.604
441.	4.569
444.	4.536
447.	4.503
450.	4.468
453.	4.435
456.	4.404
459.	4.368
462.	4.335
465.	4.304
468.	4.271
471.	4.238
474.	4.207

Time (sec)	Displacement (ft)
477.	4.176
480.	4.143
483.	4.114
486.	4.083
489.	4.05
492.	4.019
495.	3.992
498.	3.961
501.	3.93
504.	3.901
507.	3.872
510.	3.843
513.	3.814
516.	3.787
519.	3.76
522.	3.732
525.	3.705
528.	3.676
531.	3.649
534.	3.622
537.	3.595
540.	3.568
543.	3.541
546.	3.514
549.	3.49
552.	3.463
555.	3.434
558.	3.409
561.	3.384
564.	3.357
567.	3.332
570.	3.305
573.	3.283
576.	3.258
579.	3.231
582.	3.206
585.	3.186
588.	3.161
591.	3.136
594.	3.111
597.	3.091
600.	3.066
603.	3.043
606.	3.018
609.	2.995
612.	2.975
615.	2.952
618.	2.929
621.	2.906
624.	2.886
627.	2.865
630.	2.842
633.	2.82
636.	2.799
639.	2.778
642.	2.756
645.	2.735
648.	2.714
651.	2.694
654.	2.673
657.	2.652
660.	2.632
663.	2.611
666.	2.592
669.	2.57

Time (sec)	Displacement (ft)
672.	2.551
675.	2.53
678.	2.51
681.	2.491
684.	2.473
687.	2.452
690.	2.433
693.	2.415
696.	2.396
699.	2.377
702.	2.359
705.	2.338
708.	2.32
711.	2.303
714.	2.287
717.	2.268
720.	2.247
723.	2.233
726.	2.214
729.	2.198
732.	2.179
735.	2.162
738.	2.144
741.	2.127
744.	2.111
747.	2.094
750.	2.078
753.	2.061
756.	2.045
759.	2.028
762.	2.014
765.	1.995
768.	1.978
771.	1.964
774.	1.948
777.	1.931
780.	1.919
783.	1.9
786.	1.883
789.	1.869
792.	1.852
795.	1.836
798.	1.823
801.	1.809
804.	1.792
807.	1.776
810.	1.764
813.	1.747
816.	1.735
819.	1.72
822.	1.704
825.	1.689
828.	1.675
831.	1.66
834.	1.648
837.	1.633
840.	1.621
843.	1.606
846.	1.592
849.	1.577
852.	1.565
855.	1.553
858.	1.54
861.	1.526
864.	1.513

Time (sec)	Displacement (ft)
867.	1.499
870.	1.484
873.	1.472
876.	1.462
879.	1.449
882.	1.435
885.	1.422
888.	1.408
891.	1.398
894.	1.385
897.	1.373
900.	1.36
903.	1.348
906.	1.336
909.	1.323
912.	1.311
915.	1.298
918.	1.286
921.	1.276
924.	1.265
927.	1.253
930.	1.24
933.	1.23
936.	1.218
939.	1.203
942.	1.193
945.	1.183
948.	1.172
951.	1.16
954.	1.149
957.	1.137
960.	1.125
963.	1.114
966.	1.102
969.	1.092
972.	1.083
975.	1.073
978.	1.061
981.	1.05
984.	1.04
987.	1.027
990.	1.017
993.	1.007
996.	0.998
999.	0.988
1002.	0.978
1005.	0.967
1008.	0.955
1011.	0.945
1014.	0.934
1017.	0.924
1020.	0.916
1023.	0.907
1026.	0.895
1029.	0.887
1032.	0.876
1035.	0.866
1038.	0.856
1041.	0.845
1044.	0.835
1047.	0.825
1050.	0.818
1053.	0.81
1056.	0.798
1059.	0.789

Time (sec)	Displacement (ft)
1062.	0.779
1065.	0.771
1068.	0.76
1071.	0.75
1074.	0.742
1077.	0.736
1080.	0.725
1083.	0.717
1086.	0.707
1089.	0.696
1092.	0.688
1095.	0.68
1098.	0.672
1101.	0.661
1104.	0.653
1107.	0.647
1110.	0.636
1113.	0.628
1116.	0.62
1119.	0.612
1122.	0.601
1125.	0.593
1128.	0.585
1131.	0.576
1134.	0.57
1137.	0.562
1140.	0.554
1143.	0.545
1146.	0.537
1149.	0.529
1152.	0.521
1155.	0.512
1158.	0.504
1161.	0.498
1164.	0.49
1167.	0.483
1170.	0.475
1173.	0.467
1176.	0.458
1179.	0.45
1182.	0.444
1185.	0.436
1188.	0.427
1191.	0.419
1194.	0.413
1197.	0.405
1200.	0.398
1203.	0.392
1206.	0.384
1209.	0.378
1212.	0.369
1215.	0.361
1218.	0.353
1221.	0.347
1224.	0.338
1227.	0.332
1230.	0.324
1233.	0.318
1236.	0.311
1239.	0.307
1242.	0.27
1245.	0.269
1248.	0.267
1251.	0.265
1254.	0.268

Time (sec)	Displacement (ft)
1257.	0.264
1260.	0.258
1263.	0.25
1266.	0.243
1269.	0.239
1272.	0.179
1275.	0.173
1278.	0.171
1281.	0.167
1284.	0.167
1287.	0.165
1290.	0.165
1293.	0.163
1296.	0.163
1299.	0.161
1302.	0.163
1305.	0.163
1308.	0.156
1311.	0.15
1314.	0.144
1317.	0.099
1320.	0.095
1323.	0.091
1326.	0.089
1329.	0.089
1332.	0.087
1335.	0.085
1338.	0.085
1341.	0.083
1344.	0.086
1347.	0.082
1350.	0.078
1353.	0.072
1356.	0.066
1359.	0.06
1362.	0.057
1365.	0.051
1368.	0.047
1371.	0.041
1374.	0.035
1377.	0.031
1380.	0.027
1383.	0.02
1386.	0.016
1389.	0.01
1392.	0.004
1395.	0.

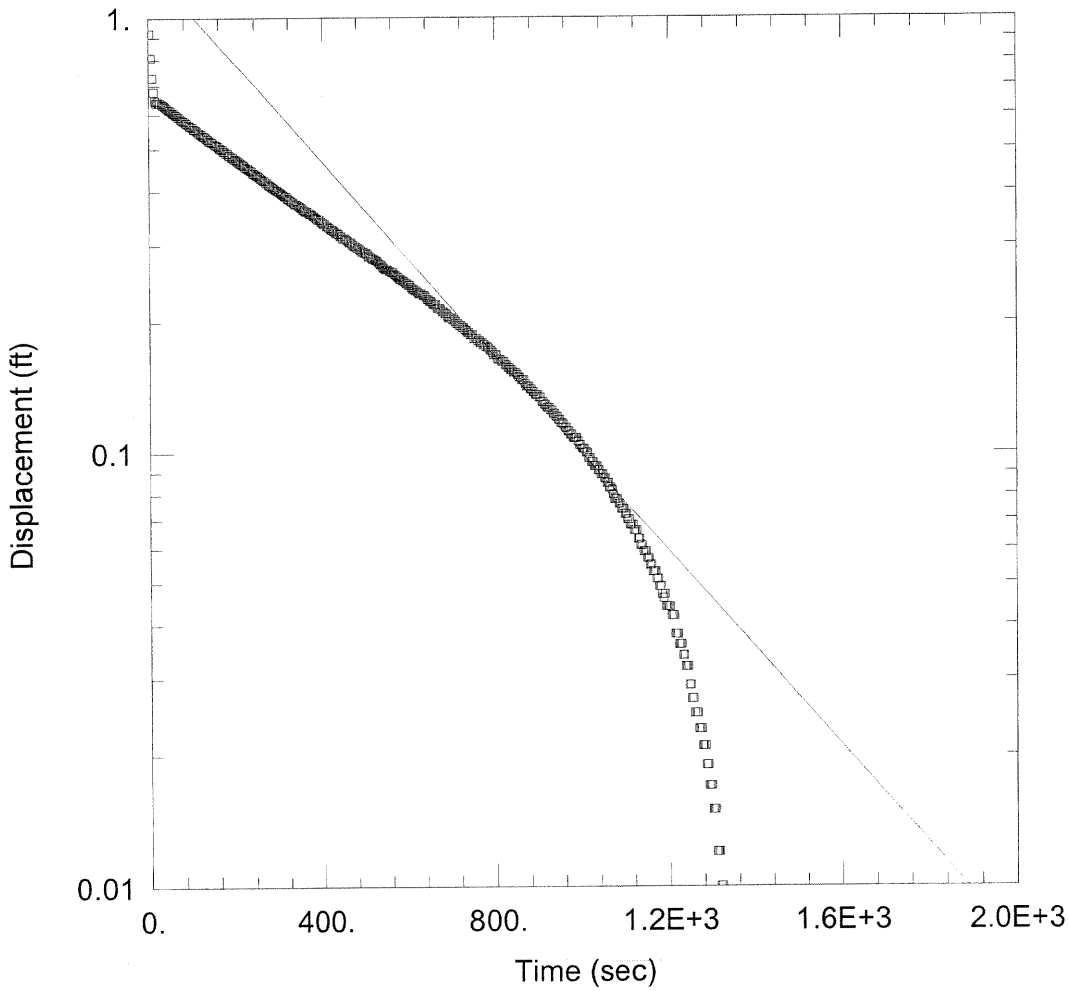
SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice
Shape Factor: 2.392

VISUAL ESTIMATION RESULTS

Estimated Parameters

Parameter	Estimate	
K	6.162E-5	cm/sec
y0	13.01	ft



CITY OF DURHAM MSWLF MW-4R

Data Set: S:\...\MW-4R.aqt
Date: 05/18/09 Time: 17:42:12

PROJECT INFORMATION

Company: S&ME
Client: City of Durham MSWLF
Project: 1054-07-469
Location: Durham, NC
Test Well: MW-4R
Test Date: April 2008

AQUIFER DATA

Saturated Thickness: 25. ft Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MW-4R)

Initial Displacement: 1.309 ft
Total Well Penetration Depth: 15.17 ft
Casing Radius: 0.083 ft
Static Water Column Height: 15.17 ft
Screen Length: 8.79 ft
Wellbore Radius: 0.3542 ft

SOLUTION

Aquifer Model: Unconfined Solution Method: Bouwer-Rice

K = 7.099E-5 cm/sec y0 = 1.308 ft

Data Set: S:\PROJECTS\2007\07-469 City of Durham MSWLF\Reports\Water Quality Monitoring Plan - Februa
Title: City of Durham MSWLF MW-4R
Date: 05/18/09
Time: 17:42:31

PROJECT INFORMATION

Company: S&ME
Client: City of Durham MSWLF
Project: 1054-07-469
Location: Durham, NC
Test Date: April 2008
Test Well: MW-4R

AQUIFER DATA

Saturated Thickness: 25. ft
Anisotropy Ratio (Kz/Kr): 1.

SLUG TEST WELL DATA

Test Well: : MW-4R

X Location: 0. ft
Y Location: 0. ft

Initial Displacement: 1.309 ft
Static Water Column Height: 15.17 ft
Casing Radius: 0.083 ft
Wellbore Radius: 0.3542 ft
Well Skin Radius: 0.3542 ft
Screen Length: 8.79 ft
Total Well Penetration Depth: 15.17 ft

No. of Observations: 452

Observation Data

Time (sec)	Displacement (ft)	Time (sec)	Displacement (ft)
3.	0.921	681.	0.211
6.	0.811	684.	0.209
9.	0.73	687.	0.209
12.	0.678	690.	0.206
15.	0.647	693.	0.204
18.	0.64	696.	0.204
21.	0.644	699.	0.204
24.	0.64	702.	0.202
27.	0.638	705.	0.202
30.	0.634	708.	0.2
33.	0.632	711.	0.198
36.	0.628	714.	0.198
39.	0.624	717.	0.196
42.	0.62	720.	0.196
45.	0.616	723.	0.194
48.	0.614	726.	0.194
51.	0.61	729.	0.192
54.	0.606	732.	0.191
57.	0.604	735.	0.189
60.	0.6	738.	0.189
63.	0.598	741.	0.187
66.	0.593	744.	0.187
69.	0.592	747.	0.187
72.	0.587	750.	0.183
75.	0.583	753.	0.183
78.	0.581	756.	0.183
81.	0.579	759.	0.181
84.	0.575	762.	0.181
87.	0.573	765.	0.179

Time (sec)	Displacement (ft)	Time (sec)	Displacement (ft)
90.	0.569	768.	0.179
93.	0.565	771.	0.177
96.	0.563	774.	0.177
99.	0.561	777.	0.175
102.	0.557	780.	0.175
105.	0.555	783.	0.174
108.	0.553	786.	0.172
111.	0.549	789.	0.172
114.	0.545	792.	0.17
117.	0.543	795.	0.168
120.	0.541	798.	0.168
123.	0.537	801.	0.168
126.	0.535	804.	0.164
129.	0.533	807.	0.164
132.	0.529	810.	0.164
135.	0.527	813.	0.162
138.	0.523	816.	0.162
141.	0.521	819.	0.162
144.	0.519	822.	0.159
147.	0.517	825.	0.159
150.	0.513	828.	0.157
153.	0.511	831.	0.157
156.	0.509	834.	0.155
159.	0.507	837.	0.155
162.	0.503	840.	0.153
165.	0.501	843.	0.153
168.	0.499	846.	0.153
171.	0.495	849.	0.151
174.	0.493	852.	0.149
177.	0.49	855.	0.149
180.	0.489	858.	0.147
183.	0.484	861.	0.147
186.	0.483	864.	0.147
189.	0.48	867.	0.144
192.	0.479	870.	0.142
195.	0.475	873.	0.142
198.	0.473	876.	0.142
201.	0.471	879.	0.14
204.	0.469	882.	0.14
207.	0.465	885.	0.138
210.	0.463	888.	0.138
213.	0.461	891.	0.136
216.	0.459	894.	0.136
219.	0.455	897.	0.136
222.	0.453	900.	0.134
225.	0.451	903.	0.134
228.	0.449	906.	0.131
231.	0.447	909.	0.131
234.	0.445	912.	0.129
237.	0.441	915.	0.129
240.	0.439	918.	0.127
243.	0.437	921.	0.127
246.	0.435	924.	0.127
249.	0.433	927.	0.125
252.	0.431	930.	0.125
255.	0.428	933.	0.123
258.	0.426	936.	0.123
261.	0.424	939.	0.121
264.	0.422	942.	0.121
267.	0.418	945.	0.119
270.	0.418	948.	0.119
273.	0.414	951.	0.117
276.	0.412	954.	0.117
279.	0.41	957.	0.116
282.	0.408	960.	0.114
285.	0.406	963.	0.114

Time (sec)	Displacement (ft)	Time (sec)	Displacement (ft)
288.	0.404	966.	0.112
291.	0.402	969.	0.112
294.	0.401	972.	0.11
297.	0.399	975.	0.11
300.	0.397	978.	0.108
303.	0.395	981.	0.108
306.	0.393	984.	0.108
309.	0.391	987.	0.108
312.	0.389	990.	0.106
315.	0.389	993.	0.104
318.	0.385	996.	0.104
321.	0.383	999.	0.102
324.	0.381	1002.	0.102
327.	0.379	1005.	0.102
330.	0.377	1008.	0.1
333.	0.375	1011.	0.1
336.	0.373	1014.	0.097
339.	0.373	1017.	0.097
342.	0.371	1020.	0.095
345.	0.369	1023.	0.095
348.	0.367	1026.	0.093
351.	0.365	1029.	0.093
354.	0.363	1032.	0.093
357.	0.361	1035.	0.091
360.	0.359	1038.	0.091
363.	0.359	1041.	0.089
366.	0.357	1044.	0.089
369.	0.355	1047.	0.089
372.	0.355	1050.	0.087
375.	0.353	1053.	0.087
378.	0.351	1056.	0.085
381.	0.349	1059.	0.085
384.	0.347	1062.	0.083
387.	0.345	1065.	0.083
390.	0.345	1068.	0.082
393.	0.343	1071.	0.08
396.	0.34	1074.	0.078
399.	0.338	1077.	0.078
402.	0.336	1080.	0.078
405.	0.336	1083.	0.076
408.	0.332	1086.	0.076
411.	0.332	1089.	0.074
414.	0.33	1092.	0.074
417.	0.328	1095.	0.074
420.	0.326	1098.	0.072
423.	0.326	1101.	0.072
426.	0.324	1104.	0.07
429.	0.322	1107.	0.07
432.	0.32	1110.	0.068
435.	0.32	1113.	0.068
438.	0.318	1116.	0.068
441.	0.315	1119.	0.066
444.	0.315	1122.	0.066
447.	0.311	1125.	0.066
450.	0.311	1128.	0.063
453.	0.311	1131.	0.063
456.	0.309	1134.	0.061
459.	0.307	1137.	0.061
462.	0.305	1140.	0.059
465.	0.305	1143.	0.059
468.	0.303	1146.	0.059
471.	0.3	1149.	0.057
474.	0.298	1152.	0.057
477.	0.298	1155.	0.055
480.	0.296	1158.	0.055
483.	0.296	1161.	0.053

Time (sec)	Displacement (ft)	Time (sec)	Displacement (ft)
486.	0.294	1164.	0.053
489.	0.292	1167.	0.053
492.	0.29	1170.	0.051
495.	0.29	1173.	0.051
498.	0.288	1176.	0.049
501.	0.288	1179.	0.049
504.	0.286	1182.	0.047
507.	0.283	1185.	0.046
510.	0.283	1188.	0.047
513.	0.281	1191.	0.044
516.	0.279	1194.	0.044
519.	0.279	1197.	0.044
522.	0.277	1200.	0.044
525.	0.277	1203.	0.042
528.	0.275	1206.	0.042
531.	0.273	1209.	0.042
534.	0.271	1212.	0.038
537.	0.271	1215.	0.038
540.	0.268	1218.	0.038
543.	0.266	1221.	0.036
546.	0.264	1224.	0.036
549.	0.264	1227.	0.036
552.	0.264	1230.	0.034
555.	0.262	1233.	0.034
558.	0.262	1236.	0.032
561.	0.26	1239.	0.032
564.	0.26	1242.	0.032
567.	0.258	1245.	0.029
570.	0.256	1248.	0.029
573.	0.255	1251.	0.027
576.	0.253	1254.	0.027
579.	0.251	1257.	0.025
582.	0.251	1260.	0.025
585.	0.249	1263.	0.025
588.	0.249	1266.	0.023
591.	0.247	1269.	0.023
594.	0.245	1272.	0.023
597.	0.245	1275.	0.021
600.	0.243	1278.	0.021
603.	0.243	1281.	0.021
606.	0.24	1284.	0.019
609.	0.238	1287.	0.019
612.	0.238	1290.	0.017
615.	0.236	1293.	0.017
618.	0.236	1296.	0.017
621.	0.234	1299.	0.015
624.	0.232	1302.	0.015
627.	0.232	1305.	0.015
630.	0.232	1308.	0.012
633.	0.23	1311.	0.012
636.	0.23	1314.	0.012
639.	0.228	1317.	0.01
642.	0.225	1320.	0.01
645.	0.225	1323.	0.008
648.	0.223	1326.	0.008
651.	0.223	1329.	0.008
654.	0.221	1332.	0.006
657.	0.219	1335.	0.006
660.	0.219	1338.	0.004
663.	0.219	1341.	0.004
666.	0.215	1344.	0.004
669.	0.215	1347.	0.002
672.	0.215	1350.	0.002
675.	0.213	1353.	0.
678.	0.211	1356.	0.

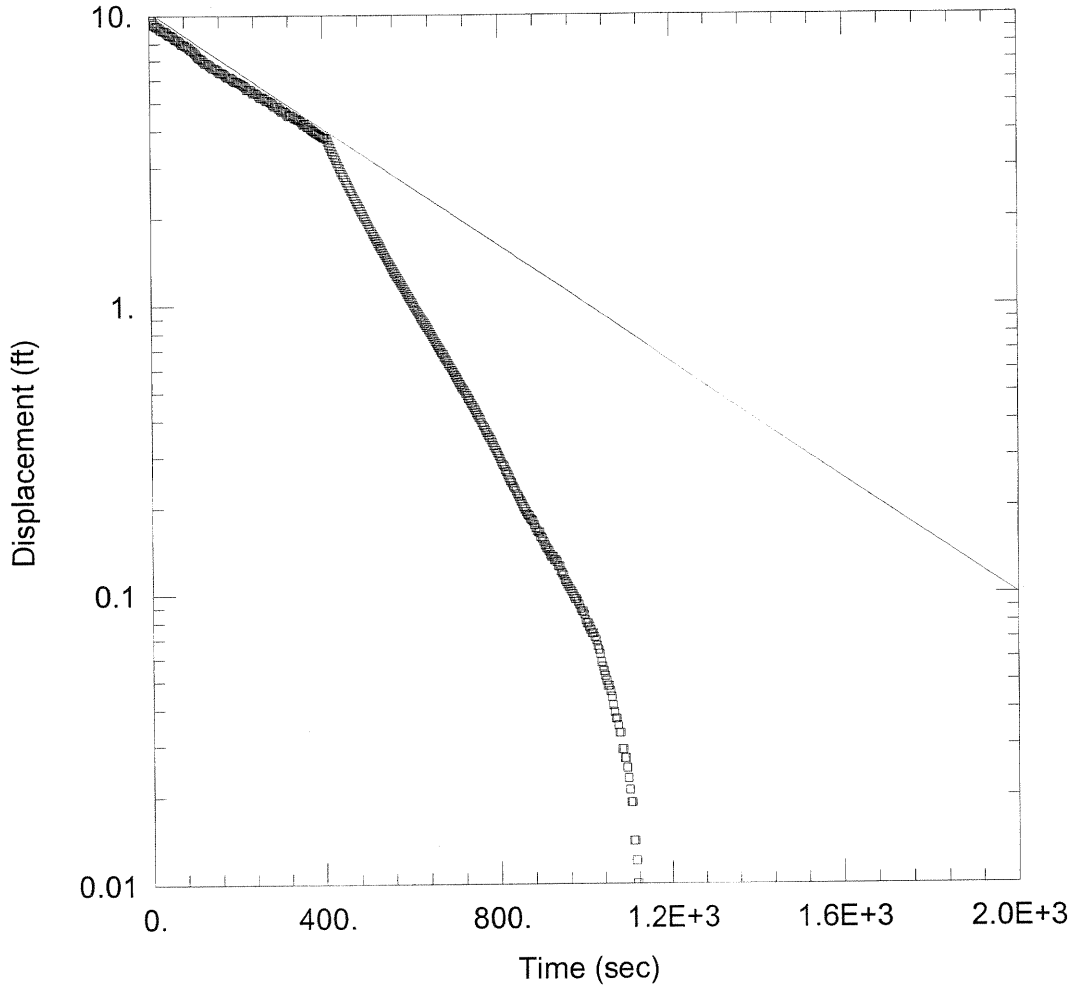
SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice
Shape Factor: 2.303

VISUAL ESTIMATION RESULTS

Estimated Parameters

Parameter	Estimate	
K	7.099E-5	cm/sec
y0	1.308	ft



CITY OF DURHAM MSWLF MW-5

Data Set: S:\...\MW-5.aqt
Date: 05/18/09 Time: 17:44:42

PROJECT INFORMATION

Company: City of Durham MSWLF
Client: City of Durham MSWLF
Project: 1054-07-469
Location: Durham, NC
Test Well: MW-5
Test Date: April 2008

AQUIFER DATA

Saturated Thickness: 25. ft
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MW-5)

Initial Displacement: 10.34 ft
Total Well Penetration Depth: 13.73 ft
Casing Radius: 0.083 ft
Static Water Column Height: 13.73 ft
Screen Length: 10. ft
Wellbore Radius: 0.3542 ft

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

K = 5.627E-5 cm/sec
y0 = 10.3 ft

Data Set: S:\PROJECTS\2007\07-469 City of Durham MSWLF\Reports\Water Quality Monitoring Plan - Februa
Title: City of Durham MSWLF MW-5
Date: 05/18/09
Time: 17:45:00

PROJECT INFORMATION

Company: City of Durham MSWLF
Client: City of Durham MSWLF
Project: 1054-07-469
Location: Durham, NC
Test Date: April 2008
Test Well: MW-5

AQUIFER DATA

Saturated Thickness: 25. ft
Anisotropy Ratio (Kz/Kr): 1.

SLUG TEST WELL DATA

Test Well: : MW-5

X Location: 0. ft
Y Location: 0. ft

Initial Displacement: 10.34 ft
Static Water Column Height: 13.73 ft
Casing Radius: 0.083 ft
Wellbore Radius: 0.3542 ft
Well Skin Radius: 0.3542 ft
Screen Length: 10. ft
Total Well Penetration Depth: 13.73 ft

No. of Observations: 379

Observation Data

Time (sec)	Displacement (ft)	Time (sec)	Displacement (ft)
3.	9.992	573.	1.222
6.	9.711	576.	1.2
9.	9.498	579.	1.179
12.	9.337	582.	1.158
15.	9.234	585.	1.138
18.	9.19	588.	1.117
21.	9.128	591.	1.096
24.	9.042	594.	1.078
27.	8.948	597.	1.059
30.	8.885	600.	1.04
33.	8.856	603.	1.022
36.	8.829	606.	1.001
39.	8.767	609.	0.985
42.	8.665	612.	0.968
45.	8.587	615.	0.952
48.	8.564	618.	0.935
51.	8.532	621.	0.917
54.	8.468	624.	0.9
57.	8.372	627.	0.886
60.	8.296	630.	0.871
63.	8.261	633.	0.855
66.	8.242	636.	0.84
69.	8.182	639.	0.826
72.	8.103	642.	0.811
75.	8.009	645.	0.797
78.	7.956	648.	0.782
81.	7.957	651.	0.768
84.	7.907	654.	0.753
87.	7.85	657.	0.741

Time (sec)	Displacement (ft)	Time (sec)	Displacement (ft)
90.	7.797	660.	0.728
93.	7.714	663.	0.716
96.	7.628	666.	0.702
99.	7.593	669.	0.689
102.	7.544	672.	0.679
105.	7.469	675.	0.664
108.	7.378	678.	0.654
111.	7.27	681.	0.644
114.	7.195	684.	0.631
117.	7.142	687.	0.619
120.	7.098	690.	0.608
123.	7.055	693.	0.596
126.	6.963	696.	0.588
129.	6.882	699.	0.575
132.	6.848	702.	0.565
135.	6.844	705.	0.555
138.	6.8	708.	0.544
141.	6.742	711.	0.534
144.	6.659	714.	0.524
147.	6.594	717.	0.515
150.	6.598	720.	0.507
153.	6.571	723.	0.497
156.	6.531	726.	0.489
159.	6.458	729.	0.478
162.	6.384	732.	0.47
165.	6.354	735.	0.46
168.	6.369	738.	0.451
171.	6.329	741.	0.443
174.	6.285	744.	0.435
177.	6.209	747.	0.426
180.	6.146	750.	0.418
183.	6.148	753.	0.41
186.	6.14	756.	0.404
189.	6.102	759.	0.393
192.	6.046	762.	0.385
195.	5.978	765.	0.379
198.	5.92	768.	0.371
201.	5.946	771.	0.363
204.	5.915	774.	0.356
207.	5.878	777.	0.35
210.	5.834	780.	0.344
213.	5.799	783.	0.336
216.	5.768	786.	0.327
219.	5.737	789.	0.321
222.	5.679	792.	0.315
225.	5.579	795.	0.309
228.	5.569	798.	0.301
231.	5.587	801.	0.295
234.	5.55	804.	0.288
237.	5.492	807.	0.282
240.	5.409	810.	0.278
243.	5.44	813.	0.27
246.	5.411	816.	0.266
249.	5.376	819.	0.259
252.	5.308	822.	0.253
255.	5.243	825.	0.247
258.	5.218	828.	0.243
261.	5.237	831.	0.237
264.	5.204	834.	0.233
267.	5.158	837.	0.228
270.	5.096	840.	0.222
273.	5.092	843.	0.218
276.	5.067	846.	0.214
279.	5.036	849.	0.21
282.	5.003	852.	0.206
285.	4.941	855.	0.201

Time (sec)	Displacement (ft)	Time (sec)	Displacement (ft)
288.	4.862	858.	0.197
291.	4.868	861.	0.193
294.	4.868	864.	0.189
297.	4.837	867.	0.187
300.	4.775	870.	0.183
303.	4.726	873.	0.181
306.	4.672	876.	0.179
309.	4.705	879.	0.174
312.	4.674	882.	0.17
315.	4.641	885.	0.166
318.	4.577	888.	0.164
321.	4.511	891.	0.164
324.	4.548	894.	0.158
327.	4.523	897.	0.156
330.	4.492	900.	0.152
333.	4.446	903.	0.148
336.	4.411	906.	0.145
339.	4.411	909.	0.143
342.	4.386	912.	0.141
345.	4.362	915.	0.137
348.	4.337	918.	0.135
351.	4.291	921.	0.135
354.	4.211	924.	0.131
357.	4.244	927.	0.131
360.	4.229	930.	0.129
363.	4.147	933.	0.125
366.	4.126	936.	0.125
369.	4.12	939.	0.12
372.	4.064	942.	0.118
375.	4.035	945.	0.116
378.	4.008	948.	0.112
381.	3.975	951.	0.11
384.	3.94	954.	0.108
387.	3.911	957.	0.106
390.	3.89	960.	0.104
393.	3.855	963.	0.102
396.	3.837	966.	0.1
399.	3.806	969.	0.098
402.	3.795	972.	0.096
405.	3.783	975.	0.096
408.	3.76	978.	0.094
411.	3.676	981.	0.092
414.	3.582	984.	0.089
417.	3.496	987.	0.087
420.	3.411	990.	0.087
423.	3.33	993.	0.085
426.	3.254	996.	0.081
429.	3.179	999.	0.079
432.	3.107	1002.	0.079
435.	3.035	1005.	0.077
438.	2.971	1008.	0.075
441.	2.902	1011.	0.073
444.	2.84	1014.	0.073
447.	2.78	1017.	0.071
450.	2.719	1020.	0.069
453.	2.661	1023.	0.066
456.	2.603	1026.	0.064
459.	2.551	1029.	0.062
462.	2.495	1032.	0.058
465.	2.444	1035.	0.056
468.	2.394	1038.	0.054
471.	2.347	1041.	0.052
474.	2.297	1044.	0.05
477.	2.249	1047.	0.048
480.	2.206	1050.	0.048
483.	2.159	1053.	0.046

Time (sec)	Displacement (ft)	Time (sec)	Displacement (ft)
486.	2.117	1056.	0.044
489.	2.074	1059.	0.041
492.	2.033	1062.	0.039
495.	1.993	1065.	0.037
498.	1.954	1068.	0.037
501.	1.915	1071.	0.035
504.	1.877	1074.	0.033
507.	1.842	1077.	0.033
510.	1.807	1080.	0.029
513.	1.77	1083.	0.029
516.	1.739	1086.	0.027
519.	1.704	1089.	0.027
522.	1.673	1092.	0.025
525.	1.642	1095.	0.023
528.	1.611	1098.	0.021
531.	1.58	1101.	0.019
534.	1.553	1104.	0.019
537.	1.522	1107.	0.014
540.	1.495	1110.	0.014
543.	1.468	1113.	0.012
546.	1.441	1116.	0.01
549.	1.415	1119.	0.008
552.	1.388	1122.	0.006
555.	1.363	1125.	0.006
558.	1.338	1128.	0.004
561.	1.313	1131.	0.002
564.	1.29	1134.	0.002
567.	1.266	1137.	0.
570.	1.243		

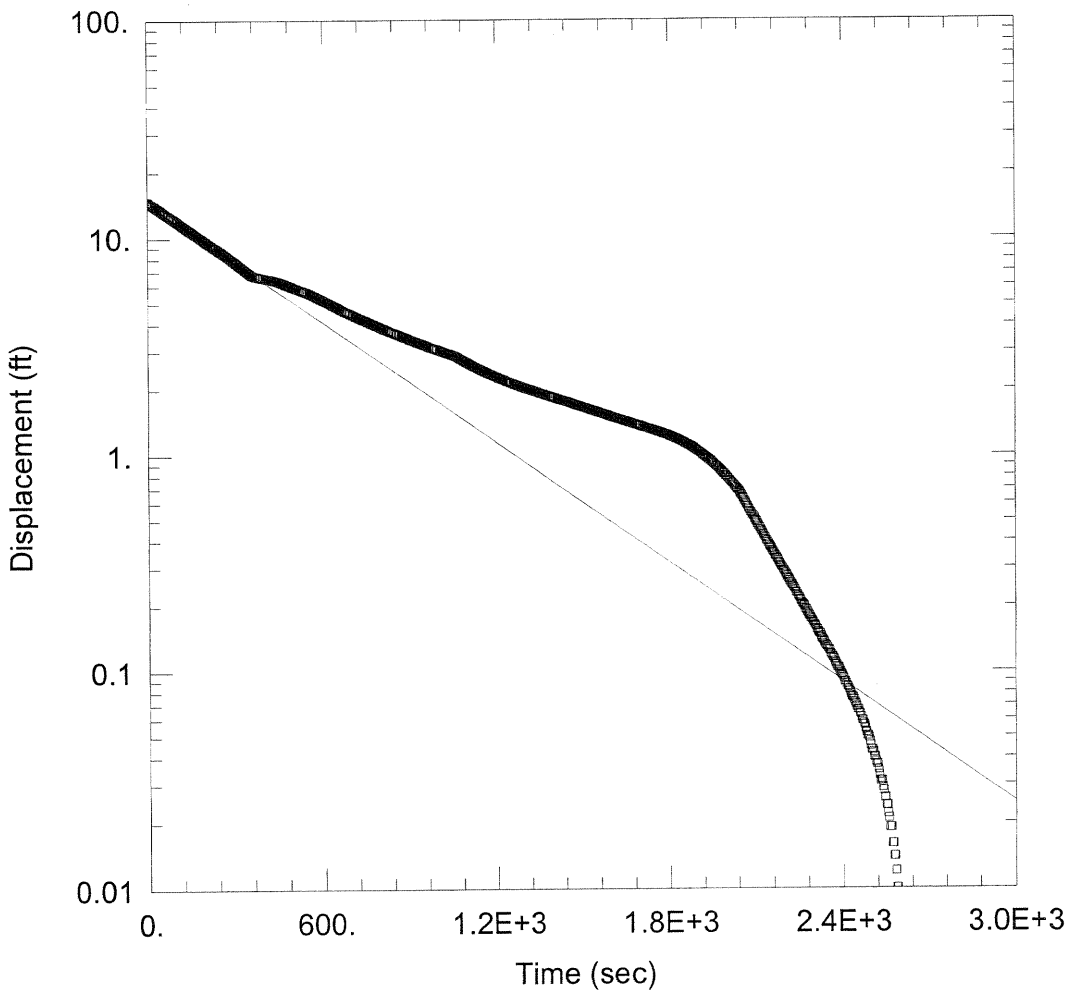
SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice
Shape Factor: 2.31

VISUAL ESTIMATION RESULTS

Estimated Parameters

Parameter	Estimate	
K	5.627E-5	cm/sec
y0	10.3	ft



CITY OF DURHAM MSWLF MW-7R

Data Set: S:\...\MW-7R.aqt
Date: 05/18/09 Time: 17:46:17

PROJECT INFORMATION

Company: S&ME
Client: City of Durham MSWLF
Project: 1054-07-469
Location: Durham, NC
Test Well: MW-7R
Test Date: April 2008

AQUIFER DATA

Saturated Thickness: 25. ft
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MW-7R)

Initial Displacement: 14.8 ft
Total Well Penetration Depth: 28.87 ft
Casing Radius: 0.083 ft
Static Water Column Height: 28.87 ft
Screen Length: 10. ft
Wellbore Radius: 0.3542 ft

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

K = 7.019E-5 cm/sec
y0 = 14.64 ft

Data Set: S:\PROJECTS\2007\07-469 City of Durham MSWLF\Reports\Water Quality Monitoring Plan - Februa
Title: City of Durham MSWLF MW-7R
Date: 05/18/09
Time: 17:46:41

PROJECT INFORMATION

Company: S&ME
Client: City of Durham MSWLF
Project: 1054-07-469
Location: Durham, NC
Test Date: April 2008
Test Well: MW-7R

AQUIFER DATA

Saturated Thickness: 25. ft
Anisotropy Ratio (Kz/Kr): 1.

SLUG TEST WELL DATA

Test Well: : MW-7R

X Location: 0. ft
Y Location: 0. ft

Initial Displacement: 14.8 ft
Static Water Column Height: 28.87 ft
Casing Radius: 0.083 ft
Wellbore Radius: 0.3542 ft
Well Skin Radius: 0.3542 ft
Screen Length: 10. ft
Total Well Penetration Depth: 28.87 ft

No. of Observations: 872

Observation Data

Time (sec)	Displacement (ft)	Time (sec)	Displacement (ft)
3.	14.7	1311.	2.006
6.	14.61	1314.	1.999
9.	14.52	1317.	1.994
12.	14.43	1320.	1.989
15.	14.34	1323.	1.982
18.	14.25	1326.	1.975
21.	14.16	1329.	1.97
24.	14.08	1332.	1.965
27.	13.99	1335.	1.958
30.	13.9	1338.	1.952
33.	13.82	1341.	1.946
36.	13.73	1344.	1.939
39.	13.65	1347.	1.933
42.	13.56	1350.	1.928
45.	13.47	1353.	1.922
48.	13.38	1356.	1.916
51.	13.3	1359.	1.911
54.	13.21	1362.	1.906
57.	13.13	1365.	1.899
60.	13.04	1368.	1.894
63.	12.96	1371.	1.887
66.	12.88	1374.	1.883
69.	12.8	1377.	1.878
72.	12.72	1380.	1.871
75.	12.64	1383.	1.868
78.	12.56	1386.	1.861
81.	12.47	1389.	1.855
84.	12.4	1392.	1.85
87.	12.32	1395.	1.845

Time (sec)	Displacement (ft)	Time (sec)	Displacement (ft)
90.	12.24	1398.	1.84
93.	12.16	1401.	1.835
96.	12.07	1404.	1.83
99.	11.99	1407.	1.824
102.	11.91	1410.	1.819
105.	11.84	1413.	1.814
108.	11.76	1416.	1.809
111.	11.68	1419.	1.804
114.	11.59	1422.	1.799
117.	11.51	1425.	1.791
120.	11.44	1428.	1.788
123.	11.36	1431.	1.783
126.	11.29	1434.	1.778
129.	11.21	1437.	1.772
132.	11.14	1440.	1.767
135.	11.07	1443.	1.762
138.	10.99	1446.	1.757
141.	10.93	1449.	1.75
144.	10.85	1452.	1.745
147.	10.79	1455.	1.74
150.	10.72	1458.	1.734
153.	10.65	1461.	1.727
156.	10.58	1464.	1.722
159.	10.52	1467.	1.719
162.	10.45	1470.	1.712
165.	10.39	1473.	1.707
168.	10.32	1476.	1.702
171.	10.26	1479.	1.696
174.	10.2	1482.	1.691
177.	10.13	1485.	1.686
180.	10.07	1488.	1.681
183.	10.	1491.	1.675
186.	9.942	1494.	1.67
189.	9.878	1497.	1.665
192.	9.816	1500.	1.662
195.	9.754	1503.	1.656
198.	9.691	1506.	1.651
201.	9.629	1509.	1.646
204.	9.563	1512.	1.641
207.	9.501	1515.	1.637
210.	9.441	1518.	1.632
213.	9.379	1521.	1.625
216.	9.318	1524.	1.622
219.	9.26	1527.	1.617
222.	9.203	1530.	1.611
225.	9.146	1533.	1.606
228.	9.089	1536.	1.601
231.	9.034	1539.	1.596
234.	8.977	1542.	1.591
237.	8.922	1545.	1.586
240.	8.865	1548.	1.581
243.	8.809	1551.	1.575
246.	8.753	1554.	1.57
249.	8.697	1557.	1.567
252.	8.642	1560.	1.562
255.	8.587	1563.	1.556
258.	8.53	1566.	1.551
261.	8.476	1569.	1.548
264.	8.423	1572.	1.542
267.	8.368	1575.	1.537
270.	8.311	1578.	1.532
273.	8.255	1581.	1.527
276.	8.198	1584.	1.523
279.	8.138	1587.	1.518
282.	8.081	1590.	1.513
285.	8.023	1593.	1.508

Time (sec)	Displacement (ft)	Time (sec)	Displacement (ft)
288.	7.964	1596.	1.503
291.	7.908	1599.	1.499
294.	7.853	1602.	1.494
297.	7.799	1605.	1.49
300.	7.75	1608.	1.485
303.	7.696	1611.	1.48
306.	7.641	1614.	1.476
309.	7.586	1617.	1.471
312.	7.531	1620.	1.468
315.	7.475	1623.	1.463
318.	7.42	1626.	1.459
321.	7.365	1629.	1.456
324.	7.311	1632.	1.451
327.	7.258	1635.	1.447
330.	7.205	1638.	1.444
333.	7.152	1641.	1.437
336.	7.099	1644.	1.433
339.	7.045	1647.	1.43
342.	6.994	1650.	1.426
345.	6.944	1653.	1.421
348.	6.896	1656.	1.418
351.	6.853	1659.	1.413
354.	6.812	1662.	1.409
357.	6.776	1665.	1.404
360.	6.744	1668.	1.4
363.	6.719	1671.	1.397
366.	6.698	1674.	1.392
369.	6.677	1677.	1.39
372.	6.659	1680.	1.387
375.	6.644	1683.	1.38
378.	6.63	1686.	1.376
381.	6.616	1689.	1.373
384.	6.604	1692.	1.369
387.	6.591	1695.	1.366
390.	6.579	1698.	1.362
393.	6.567	1701.	1.357
396.	6.555	1704.	1.354
399.	6.542	1707.	1.349
402.	6.532	1710.	1.347
405.	6.519	1713.	1.342
408.	6.509	1716.	1.336
411.	6.498	1719.	1.333
414.	6.486	1722.	1.329
417.	6.475	1725.	1.324
420.	6.463	1728.	1.323
423.	6.451	1731.	1.317
426.	6.439	1734.	1.314
429.	6.426	1737.	1.309
432.	6.411	1740.	1.305
435.	6.392	1743.	1.302
438.	6.373	1746.	1.298
441.	6.354	1749.	1.293
444.	6.335	1752.	1.29
447.	6.319	1755.	1.286
450.	6.298	1758.	1.281
453.	6.279	1761.	1.277
456.	6.259	1764.	1.274
459.	6.238	1767.	1.269
462.	6.214	1770.	1.266
465.	6.19	1773.	1.26
468.	6.166	1776.	1.257
471.	6.139	1779.	1.252
474.	6.115	1782.	1.248
477.	6.091	1785.	1.245
480.	6.067	1788.	1.241
483.	6.043	1791.	1.236

Time (sec)	Displacement (ft)	Time (sec)	Displacement (ft)
486.	6.022	1794.	1.233
489.	5.997	1797.	1.228
492.	5.974	1800.	1.222
495.	5.952	1803.	1.217
498.	5.929	1806.	1.214
501.	5.912	1809.	1.209
504.	5.893	1812.	1.203
507.	5.874	1815.	1.198
510.	5.851	1818.	1.195
513.	5.831	1821.	1.19
516.	5.812	1824.	1.184
519.	5.791	1827.	1.179
522.	5.772	1830.	1.174
525.	5.751	1833.	1.169
528.	5.73	1836.	1.164
531.	5.71	1839.	1.158
534.	5.687	1842.	1.153
537.	5.668	1845.	1.148
540.	5.648	1848.	1.143
543.	5.627	1851.	1.136
546.	5.606	1854.	1.131
549.	5.584	1857.	1.126
552.	5.563	1860.	1.121
555.	5.541	1863.	1.114
558.	5.52	1866.	1.109
561.	5.493	1869.	1.102
564.	5.467	1872.	1.097
567.	5.441	1875.	1.091
570.	5.415	1878.	1.085
573.	5.388	1881.	1.079
576.	5.362	1884.	1.071
579.	5.338	1887.	1.064
582.	5.312	1890.	1.057
585.	5.286	1893.	1.05
588.	5.262	1896.	1.045
591.	5.238	1899.	1.037
594.	5.214	1902.	1.03
597.	5.19	1905.	1.024
600.	5.166	1908.	1.018
603.	5.143	1911.	1.011
606.	5.119	1914.	1.002
609.	5.097	1917.	0.995
612.	5.075	1920.	0.988
615.	5.052	1923.	0.982
618.	5.03	1926.	0.975
621.	5.008	1929.	0.968
624.	4.985	1932.	0.961
627.	4.963	1935.	0.952
630.	4.939	1938.	0.947
633.	4.916	1941.	0.939
636.	4.894	1944.	0.932
639.	4.871	1947.	0.925
642.	4.849	1950.	0.916
645.	4.825	1953.	0.909
648.	4.803	1956.	0.903
651.	4.78	1959.	0.896
654.	4.758	1962.	0.887
657.	4.736	1965.	0.88
660.	4.71	1968.	0.873
663.	4.687	1971.	0.865
666.	4.667	1974.	0.858
669.	4.643	1977.	0.849
672.	4.624	1980.	0.841
675.	4.601	1983.	0.832
678.	4.582	1986.	0.825
681.	4.562	1989.	0.817

Time (sec)	Displacement (ft)	Time (sec)	Displacement (ft)
684.	4.541	1992.	0.81
687.	4.521	1995.	0.801
690.	4.5	1998.	0.795
693.	4.481	2001.	0.786
696.	4.46	2004.	0.777
699.	4.44	2007.	0.771
702.	4.419	2010.	0.762
705.	4.4	2013.	0.755
708.	4.379	2016.	0.747
711.	4.359	2019.	0.74
714.	4.341	2022.	0.731
717.	4.323	2025.	0.722
720.	4.304	2028.	0.716
723.	4.286	2031.	0.707
726.	4.269	2034.	0.7
729.	4.252	2037.	0.693
732.	4.233	2040.	0.685
735.	4.216	2043.	0.676
738.	4.198	2046.	0.668
741.	4.183	2049.	0.657
744.	4.166	2052.	0.647
747.	4.149	2055.	0.635
750.	4.131	2058.	0.625
753.	4.114	2061.	0.613
756.	4.097	2064.	0.603
759.	4.081	2067.	0.592
762.	4.062	2070.	0.582
765.	4.047	2073.	0.572
768.	4.03	2076.	0.562
771.	4.012	2079.	0.553
774.	3.997	2082.	0.543
777.	3.981	2085.	0.536
780.	3.964	2088.	0.527
783.	3.949	2091.	0.521
786.	3.935	2094.	0.512
789.	3.918	2097.	0.503
792.	3.902	2100.	0.495
795.	3.887	2103.	0.488
798.	3.871	2106.	0.478
801.	3.856	2109.	0.469
804.	3.84	2112.	0.462
807.	3.824	2115.	0.455
810.	3.811	2118.	0.447
813.	3.794	2121.	0.44
816.	3.78	2124.	0.431
819.	3.764	2127.	0.425
822.	3.752	2130.	0.417
825.	3.737	2133.	0.411
828.	3.723	2136.	0.402
831.	3.709	2139.	0.397
834.	3.693	2142.	0.39
837.	3.681	2145.	0.383
840.	3.668	2148.	0.378
843.	3.654	2151.	0.373
846.	3.64	2154.	0.366
849.	3.626	2157.	0.359
852.	3.612	2160.	0.356
855.	3.598	2163.	0.349
858.	3.585	2166.	0.342
861.	3.573	2169.	0.339
864.	3.559	2172.	0.332
867.	3.545	2175.	0.327
870.	3.533	2178.	0.322
873.	3.521	2181.	0.315
876.	3.505	2184.	0.311
879.	3.492	2187.	0.306

Time (sec)	Displacement (ft)	Time (sec)	Displacement (ft)
882.	3.478	2190.	0.301
885.	3.466	2193.	0.296
888.	3.452	2196.	0.291
891.	3.438	2199.	0.287
894.	3.426	2202.	0.282
897.	3.414	2205.	0.277
900.	3.4	2208.	0.273
903.	3.388	2211.	0.268
906.	3.376	2214.	0.265
909.	3.364	2217.	0.26
912.	3.352	2220.	0.255
915.	3.338	2223.	0.251
918.	3.326	2226.	0.248
921.	3.316	2229.	0.244
924.	3.302	2232.	0.241
927.	3.291	2235.	0.236
930.	3.281	2238.	0.23
933.	3.269	2241.	0.229
936.	3.257	2244.	0.224
939.	3.246	2247.	0.22
942.	3.234	2250.	0.217
945.	3.224	2253.	0.213
948.	3.212	2256.	0.21
951.	3.202	2259.	0.206
954.	3.19	2262.	0.203
957.	3.179	2265.	0.201
960.	3.171	2268.	0.198
963.	3.158	2271.	0.192
966.	3.146	2274.	0.191
969.	3.138	2277.	0.187
972.	3.126	2280.	0.184
975.	3.115	2283.	0.181
978.	3.105	2286.	0.179
981.	3.096	2289.	0.175
984.	3.084	2292.	0.173
987.	3.075	2295.	0.17
990.	3.065	2298.	0.167
993.	3.055	2301.	0.165
996.	3.044	2304.	0.162
999.	3.034	2307.	0.16
1002.	3.024	2310.	0.156
1005.	3.015	2313.	0.154
1008.	3.005	2316.	0.151
1011.	2.994	2319.	0.149
1014.	2.984	2322.	0.148
1017.	2.975	2325.	0.144
1020.	2.967	2328.	0.141
1023.	2.958	2331.	0.139
1026.	2.948	2334.	0.137
1029.	2.939	2337.	0.135
1032.	2.93	2340.	0.132
1035.	2.921	2343.	0.13
1038.	2.911	2346.	0.129
1041.	2.902	2349.	0.127
1044.	2.894	2352.	0.125
1047.	2.885	2355.	0.124
1050.	2.875	2358.	0.12
1053.	2.866	2361.	0.118
1056.	2.858	2364.	0.116
1059.	2.847	2367.	0.115
1062.	2.834	2370.	0.113
1065.	2.818	2373.	0.11
1068.	2.803	2376.	0.108
1071.	2.787	2379.	0.106
1074.	2.772	2382.	0.104
1077.	2.756	2385.	0.103

Time (sec)	Displacement (ft)	Time (sec)	Displacement (ft)
1080.	2.742	2388.	0.101
1083.	2.729	2391.	0.099
1086.	2.713	2394.	0.097
1089.	2.699	2397.	0.096
1092.	2.686	2400.	0.094
1095.	2.672	2403.	0.092
1098.	2.657	2406.	0.089
1101.	2.644	2409.	0.089
1104.	2.631	2412.	0.087
1107.	2.617	2415.	0.085
1110.	2.607	2418.	0.084
1113.	2.593	2421.	0.082
1116.	2.579	2424.	0.08
1119.	2.567	2427.	0.078
1122.	2.555	2430.	0.076
1125.	2.543	2433.	0.075
1128.	2.531	2436.	0.075
1131.	2.519	2439.	0.073
1134.	2.507	2442.	0.071
1137.	2.495	2445.	0.07
1140.	2.483	2448.	0.068
1143.	2.472	2451.	0.066
1146.	2.462	2454.	0.066
1149.	2.452	2457.	0.064
1152.	2.44	2460.	0.063
1155.	2.429	2463.	0.061
1158.	2.419	2466.	0.059
1161.	2.409	2469.	0.059
1164.	2.398	2472.	0.057
1167.	2.386	2475.	0.056
1170.	2.378	2478.	0.054
1173.	2.369	2481.	0.052
1176.	2.359	2484.	0.05
1179.	2.35	2487.	0.05
1182.	2.34	2490.	0.049
1185.	2.331	2493.	0.047
1188.	2.321	2496.	0.045
1191.	2.312	2499.	0.043
1194.	2.302	2502.	0.043
1197.	2.293	2505.	0.042
1200.	2.284	2508.	0.04
1203.	2.276	2511.	0.04
1206.	2.267	2514.	0.038
1209.	2.259	2517.	0.037
1212.	2.25	2520.	0.037
1215.	2.241	2523.	0.035
1218.	2.233	2526.	0.033
1221.	2.224	2529.	0.031
1224.	2.217	2532.	0.031
1227.	2.208	2535.	0.031
1230.	2.2	2538.	0.029
1233.	2.191	2541.	0.028
1236.	2.184	2544.	0.026
1239.	2.176	2547.	0.026
1242.	2.169	2550.	0.024
1245.	2.16	2553.	0.024
1248.	2.153	2556.	0.022
1251.	2.145	2559.	0.021
1254.	2.138	2562.	0.019
1257.	2.129	2565.	0.019
1260.	2.122	2568.	0.019
1263.	2.115	2571.	0.016
1266.	2.108	2574.	0.016
1269.	2.101	2577.	0.014
1272.	2.094	2580.	0.014
1275.	2.086	2583.	0.012

Time (sec)	Displacement (ft)	Time (sec)	Displacement (ft)
1278.	2.081	2586.	0.01
1281.	2.074	2589.	0.01
1284.	2.065	2592.	0.008
1287.	2.06	2595.	0.007
1290.	2.051	2598.	0.007
1293.	2.044	2601.	0.005
1296.	2.037	2604.	0.003
1299.	2.03	2607.	0.003
1302.	2.024	2610.	0.003
1305.	2.018	2613.	0.001
1308.	2.011	2616.	0.

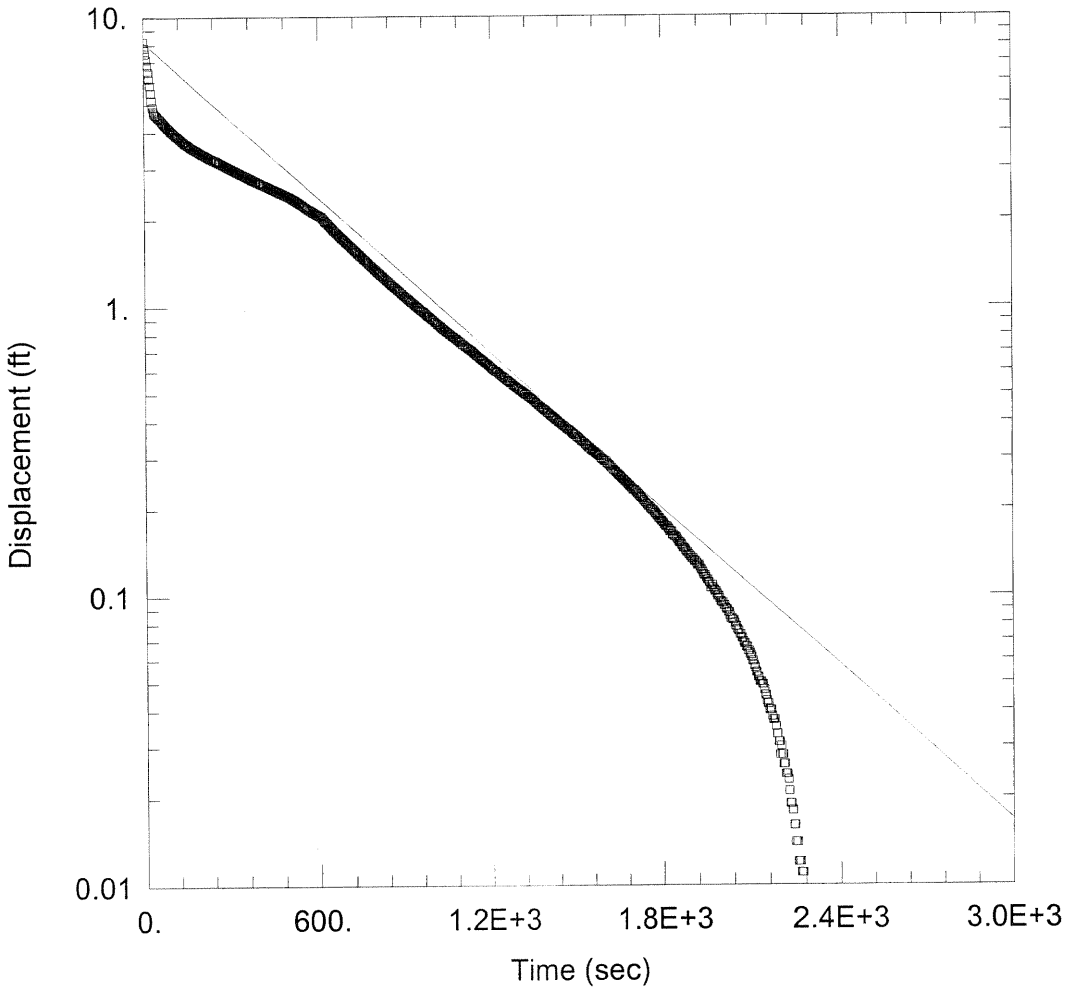
SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice
Shape Factor: 3.147

VISUAL ESTIMATION RESULTS

Estimated Parameters

Parameter	Estimate	
K	7.019E-5	cm/sec
y0	14.64	ft



CITY OF DURHAM MSWLF MW-9R

Data Set: S:\...\MW-9R.aqt
Date: 05/18/09 Time: 17:40:30

PROJECT INFORMATION

Company: S&ME
Client: City of Durham MSWLF
Project: 1054-07-469
Location: Durham, NC
Test Well: MW-9R
Test Date: April 2008

AQUIFER DATA

Saturated Thickness: 25. ft
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MW-9R)

Initial Displacement: 8.214 ft
Total Well Penetration Depth: 10.44 ft
Casing Radius: 0.083 ft
Static Water Column Height: 10.44 ft
Screen Length: 10. ft
Wellbore Radius: 0.3542 ft

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

K = 4.705E-5 cm/sec
y0 = 8.211 ft

Data Set: S:\PROJECTS\2007\07-469 City of Durham MSWLF\Reports\Water Quality Monitoring Plan - Februa
Title: City of Durham MSWLF MW-9R
Date: 05/18/09
Time: 17:40:58

PROJECT INFORMATION

Company: S&ME
Client: City of Durham MSWLF
Project: 1054-07-469
Location: Durham, NC
Test Date: April 2008
Test Well: MW-9R

AQUIFER DATA

Saturated Thickness: 25. ft
Anisotropy Ratio (Kz/Kr): 1.

SLUG TEST WELL DATA

Test Well: : MW-9R

X Location: 0. ft
Y Location: 0. ft

Initial Displacement: 8.214 ft
Static Water Column Height: 10.44 ft
Casing Radius: 0.083 ft
Wellbore Radius: 0.3542 ft
Well Skin Radius: 0.3542 ft
Screen Length: 10. ft
Total Well Penetration Depth: 10.44 ft

No. of Observations: 768

Observation Data

Time (sec)	Displacement (ft)	Time (sec)	Displacement (ft)
3.	7.862	1155.	0.667
6.	7.508	1158.	0.664
9.	7.163	1161.	0.66
12.	6.819	1164.	0.657
15.	6.48	1167.	0.653
18.	6.146	1170.	0.65
21.	5.816	1173.	0.646
24.	5.489	1176.	0.641
27.	5.173	1179.	0.639
30.	4.905	1182.	0.636
33.	4.744	1185.	0.632
36.	4.671	1188.	0.629
39.	4.628	1191.	0.625
42.	4.596	1194.	0.622
45.	4.563	1197.	0.617
48.	4.529	1200.	0.613
51.	4.497	1203.	0.61
54.	4.464	1206.	0.606
57.	4.433	1209.	0.603
60.	4.398	1212.	0.599
63.	4.363	1215.	0.598
66.	4.326	1218.	0.596
69.	4.293	1221.	0.592
72.	4.263	1224.	0.589
75.	4.233	1227.	0.585
78.	4.201	1230.	0.582
81.	4.168	1233.	0.578
84.	4.137	1236.	0.577
87.	4.107	1239.	0.573

Time (sec)	Displacement (ft)	Time (sec)	Displacement (ft)
90.	4.079	1242.	0.57
93.	4.049	1245.	0.566
96.	4.023	1248.	0.565
99.	3.997	1251.	0.559
102.	3.974	1254.	0.557
105.	3.951	1257.	0.554
108.	3.928	1260.	0.551
111.	3.909	1263.	0.549
114.	3.886	1266.	0.545
117.	3.865	1269.	0.544
120.	3.844	1272.	0.54
123.	3.821	1275.	0.535
126.	3.797	1278.	0.533
129.	3.774	1281.	0.53
132.	3.751	1284.	0.528
135.	3.727	1287.	0.524
138.	3.706	1290.	0.523
141.	3.685	1293.	0.519
144.	3.667	1296.	0.518
147.	3.65	1299.	0.514
150.	3.633	1302.	0.512
153.	3.613	1305.	0.509
156.	3.594	1308.	0.507
159.	3.577	1311.	0.503
162.	3.563	1314.	0.502
165.	3.547	1317.	0.498
168.	3.533	1320.	0.497
171.	3.517	1323.	0.495
174.	3.505	1326.	0.491
177.	3.489	1329.	0.488
180.	3.477	1332.	0.486
183.	3.463	1335.	0.483
186.	3.451	1338.	0.481
189.	3.437	1341.	0.479
192.	3.423	1344.	0.476
195.	3.409	1347.	0.474
198.	3.397	1350.	0.47
201.	3.383	1353.	0.467
204.	3.371	1356.	0.465
207.	3.359	1359.	0.462
210.	3.346	1362.	0.458
213.	3.334	1365.	0.456
216.	3.322	1368.	0.455
219.	3.31	1371.	0.451
222.	3.297	1374.	0.449
225.	3.285	1377.	0.446
228.	3.273	1380.	0.444
231.	3.261	1383.	0.443
234.	3.249	1386.	0.439
237.	3.238	1389.	0.437
240.	3.228	1392.	0.436
243.	3.219	1395.	0.432
246.	3.207	1398.	0.43
249.	3.197	1401.	0.427
252.	3.185	1404.	0.425
255.	3.172	1407.	0.422
258.	3.16	1410.	0.42
261.	3.148	1413.	0.418
264.	3.136	1416.	0.415
267.	3.126	1419.	0.413
270.	3.113	1422.	0.411
273.	3.101	1425.	0.409
276.	3.091	1428.	0.406
279.	3.081	1431.	0.404
282.	3.07	1434.	0.402
285.	3.058	1437.	0.399

Time (sec)	Displacement (ft)	Time (sec)	Displacement (ft)
288.	3.048	1440.	0.397
291.	3.035	1443.	0.395
294.	3.025	1446.	0.394
297.	3.013	1449.	0.39
300.	3.002	1452.	0.389
303.	2.992	1455.	0.387
306.	2.98	1458.	0.385
309.	2.968	1461.	0.383
312.	2.959	1464.	0.38
315.	2.947	1467.	0.378
318.	2.938	1470.	0.376
321.	2.928	1473.	0.375
324.	2.916	1476.	0.373
327.	2.907	1479.	0.371
330.	2.895	1482.	0.368
333.	2.887	1485.	0.366
336.	2.876	1488.	0.364
339.	2.866	1491.	0.362
342.	2.855	1494.	0.359
345.	2.845	1497.	0.359
348.	2.836	1500.	0.355
351.	2.826	1503.	0.354
354.	2.816	1506.	0.352
357.	2.805	1509.	0.35
360.	2.795	1512.	0.347
363.	2.786	1515.	0.345
366.	2.776	1518.	0.343
369.	2.765	1521.	0.341
372.	2.757	1524.	0.338
375.	2.746	1527.	0.338
378.	2.736	1530.	0.335
381.	2.727	1533.	0.333
384.	2.718	1536.	0.331
387.	2.708	1539.	0.329
390.	2.698	1542.	0.326
393.	2.692	1545.	0.326
396.	2.682	1548.	0.322
399.	2.673	1551.	0.32
402.	2.663	1554.	0.319
405.	2.656	1557.	0.317
408.	2.647	1560.	0.315
411.	2.638	1563.	0.314
414.	2.631	1566.	0.312
417.	2.622	1569.	0.31
420.	2.614	1572.	0.308
423.	2.607	1575.	0.307
426.	2.598	1578.	0.305
429.	2.589	1581.	0.303
432.	2.58	1584.	0.299
435.	2.572	1587.	0.298
438.	2.563	1590.	0.296
441.	2.556	1593.	0.294
444.	2.547	1596.	0.293
447.	2.539	1599.	0.292
450.	2.53	1602.	0.291
453.	2.521	1605.	0.287
456.	2.513	1608.	0.286
459.	2.506	1611.	0.284
462.	2.497	1614.	0.282
465.	2.488	1617.	0.28
468.	2.479	1620.	0.277
471.	2.472	1623.	0.277
474.	2.464	1626.	0.273
477.	2.455	1629.	0.272
480.	2.446	1632.	0.27
483.	2.439	1635.	0.268

Time (sec)	Displacement (ft)	Time (sec)	Displacement (ft)
486.	2.43	1638.	0.267
489.	2.423	1641.	0.265
492.	2.416	1644.	0.263
495.	2.406	1647.	0.261
498.	2.399	1650.	0.26
501.	2.39	1653.	0.258
504.	2.381	1656.	0.256
507.	2.373	1659.	0.254
510.	2.361	1662.	0.252
513.	2.352	1665.	0.251
516.	2.343	1668.	0.249
519.	2.333	1671.	0.247
522.	2.324	1674.	0.246
525.	2.314	1677.	0.244
528.	2.303	1680.	0.242
531.	2.295	1683.	0.24
534.	2.284	1686.	0.239
537.	2.274	1689.	0.237
540.	2.263	1692.	0.235
543.	2.251	1695.	0.233
546.	2.241	1698.	0.232
549.	2.229	1701.	0.232
552.	2.218	1704.	0.23
555.	2.208	1707.	0.228
558.	2.196	1710.	0.226
561.	2.186	1713.	0.225
564.	2.175	1716.	0.223
567.	2.167	1719.	0.221
570.	2.158	1722.	0.219
573.	2.149	1725.	0.218
576.	2.14	1728.	0.216
579.	2.13	1731.	0.214
582.	2.121	1734.	0.213
585.	2.113	1737.	0.211
588.	2.104	1740.	0.209
591.	2.095	1743.	0.207
594.	2.088	1746.	0.206
597.	2.08	1749.	0.204
600.	2.071	1752.	0.204
603.	2.064	1755.	0.202
606.	2.055	1758.	0.2
609.	2.047	1761.	0.199
612.	2.033	1764.	0.197
615.	2.016	1767.	0.197
618.	2.	1770.	0.195
621.	1.985	1773.	0.193
624.	1.969	1776.	0.192
627.	1.955	1779.	0.19
630.	1.94	1782.	0.188
633.	1.926	1785.	0.185
636.	1.912	1788.	0.185
639.	1.897	1791.	0.183
642.	1.885	1794.	0.181
645.	1.869	1797.	0.181
648.	1.857	1800.	0.179
651.	1.843	1803.	0.178
654.	1.83	1806.	0.176
657.	1.817	1809.	0.174
660.	1.805	1812.	0.173
663.	1.792	1815.	0.173
666.	1.779	1818.	0.171
669.	1.767	1821.	0.169
672.	1.755	1824.	0.167
675.	1.745	1827.	0.166
678.	1.733	1830.	0.166
681.	1.721	1833.	0.162

Time (sec)	Displacement (ft)	Time (sec)	Displacement (ft)
684.	1.709	1836.	0.162
687.	1.699	1839.	0.16
690.	1.686	1842.	0.16
693.	1.674	1845.	0.159
696.	1.664	1848.	0.157
699.	1.654	1851.	0.155
702.	1.643	1854.	0.153
705.	1.631	1857.	0.152
708.	1.621	1860.	0.152
711.	1.609	1863.	0.15
714.	1.599	1866.	0.148
717.	1.587	1869.	0.146
720.	1.576	1872.	0.146
723.	1.566	1875.	0.145
726.	1.555	1878.	0.143
729.	1.545	1881.	0.141
732.	1.535	1884.	0.141
735.	1.524	1887.	0.139
738.	1.514	1890.	0.138
741.	1.504	1893.	0.136
744.	1.493	1896.	0.136
747.	1.483	1899.	0.134
750.	1.474	1902.	0.134
753.	1.464	1905.	0.132
756.	1.455	1908.	0.131
759.	1.447	1911.	0.131
762.	1.438	1914.	0.129
765.	1.428	1917.	0.127
768.	1.419	1920.	0.127
771.	1.409	1923.	0.127
774.	1.4	1926.	0.125
777.	1.39	1929.	0.123
780.	1.383	1932.	0.122
783.	1.374	1935.	0.12
786.	1.364	1938.	0.118
789.	1.355	1941.	0.117
792.	1.348	1944.	0.117
795.	1.34	1947.	0.115
798.	1.329	1950.	0.113
801.	1.321	1953.	0.113
804.	1.314	1956.	0.111
807.	1.304	1959.	0.11
810.	1.297	1962.	0.106
813.	1.286	1965.	0.108
816.	1.279	1968.	0.108
819.	1.272	1971.	0.106
822.	1.264	1974.	0.104
825.	1.257	1977.	0.103
828.	1.248	1980.	0.103
831.	1.24	1983.	0.101
834.	1.233	1986.	0.099
837.	1.224	1989.	0.099
840.	1.217	1992.	0.097
843.	1.209	1995.	0.095
846.	1.202	1998.	0.095
849.	1.193	2001.	0.094
852.	1.186	2004.	0.094
855.	1.179	2007.	0.092
858.	1.171	2010.	0.092
861.	1.165	2013.	0.09
864.	1.159	2016.	0.089
867.	1.152	2019.	0.089
870.	1.145	2022.	0.087
873.	1.138	2025.	0.087
876.	1.133	2028.	0.085
879.	1.126	2031.	0.083

Time (sec)	Displacement (ft)	Time (sec)	Displacement (ft)
882.	1.117	2034.	0.083
885.	1.11	2037.	0.082
888.	1.105	2040.	0.082
891.	1.096	2043.	0.08
894.	1.091	2046.	0.078
897.	1.084	2049.	0.078
900.	1.079	2052.	0.076
903.	1.072	2055.	0.075
906.	1.065	2058.	0.075
909.	1.058	2061.	0.073
912.	1.053	2064.	0.073
915.	1.046	2067.	0.071
918.	1.039	2070.	0.071
921.	1.034	2073.	0.069
924.	1.029	2076.	0.068
927.	1.022	2079.	0.068
930.	1.017	2082.	0.066
933.	1.01	2085.	0.066
936.	1.005	2088.	0.064
939.	1.	2091.	0.064
942.	0.993	2094.	0.063
945.	0.989	2097.	0.062
948.	0.984	2100.	0.061
951.	0.977	2103.	0.059
954.	0.972	2106.	0.059
957.	0.967	2109.	0.057
960.	0.96	2112.	0.056
963.	0.955	2115.	0.054
966.	0.949	2118.	0.054
969.	0.944	2121.	0.052
972.	0.937	2124.	0.052
975.	0.932	2127.	0.05
978.	0.927	2130.	0.05
981.	0.922	2133.	0.05
984.	0.917	2136.	0.049
987.	0.911	2139.	0.049
990.	0.906	2142.	0.047
993.	0.901	2145.	0.045
996.	0.896	2148.	0.045
999.	0.891	2151.	0.043
1002.	0.885	2154.	0.042
1005.	0.88	2157.	0.042
1008.	0.875	2160.	0.04
1011.	0.87	2163.	0.04
1014.	0.865	2166.	0.04
1017.	0.859	2169.	0.038
1020.	0.854	2172.	0.037
1023.	0.849	2175.	0.037
1026.	0.844	2178.	0.037
1029.	0.84	2181.	0.035
1032.	0.834	2184.	0.033
1035.	0.83	2187.	0.033
1038.	0.825	2190.	0.031
1041.	0.82	2193.	0.031
1044.	0.816	2196.	0.028
1047.	0.811	2199.	0.03
1050.	0.806	2202.	0.028
1053.	0.802	2205.	0.028
1056.	0.799	2208.	0.026
1059.	0.794	2211.	0.026
1062.	0.79	2214.	0.024
1065.	0.787	2217.	0.024
1068.	0.783	2220.	0.024
1071.	0.778	2223.	0.023
1074.	0.775	2226.	0.021
1077.	0.771	2229.	0.019

Time (sec)	Displacement (ft)	Time (sec)	Displacement (ft)
1080.	0.766	2232.	0.019
1083.	0.761	2235.	0.018
1086.	0.757	2238.	0.018
1089.	0.752	2241.	0.016
1092.	0.749	2244.	0.016
1095.	0.743	2247.	0.014
1098.	0.74	2250.	0.014
1101.	0.736	2253.	0.014
1104.	0.731	2256.	0.012
1107.	0.728	2259.	0.012
1110.	0.723	2262.	0.012
1113.	0.719	2265.	0.011
1116.	0.717	2268.	0.011
1119.	0.714	2271.	0.011
1122.	0.71	2274.	0.009
1125.	0.707	2277.	0.009
1128.	0.704	2280.	0.007
1131.	0.7	2283.	0.005
1134.	0.695	2286.	0.005
1137.	0.691	2289.	0.003
1140.	0.688	2292.	0.005
1143.	0.683	2295.	0.003
1146.	0.679	2298.	0.002
1149.	0.676	2301.	0.002
1152.	0.672	2304.	0.

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice
Shape Factor: 2.17

VISUAL ESTIMATION RESULTS

Estimated Parameters

Parameter	Estimate	
K	4.705E-5	cm/sec
y0	8.211	ft

APPENDIX II

WELL CONSTRUCTION RECORDS
& SOIL BORING LOGS

Borehole Log

NFE Technologies, Inc.
250 Dominion Dr., Morrisville, NC 27560
Ph: 919-469-4800 Fx: 919-319-8400

City of Durham Landfill
Piezometer Installation
East Club Blvd.
Durham, NC

JOB NO.: 03-271
LOG OF: P-2R
Sheet 1 OF 2

DRILLER: Marty Shaver
DATE DRILLED: 6/9/2004
DRILL METHOD: 4.25 ID HSA

GROUND SURFACE ELEVATION: ft.
TOP OF CASING ELEVATION: ft.
WATER LEVEL: 28.16 ft. bls Date: 6/10/2004

Recovery	Blow Counts			Depth (ft.)	Graphic Log	Materials Description	Well Construction
						yellow/brown silt	
						yellow/gray silt	Cement grout
						light brown silt	
				5			2" Sch 40 PVC
				10		light brown silt with fine sand	Bentonite Seal
				15			Silica Sand Filter Pack
				20		brown sandy silt with rock fragments	2" Sch 40 PVC 0.010 Slot Screen
				25		slow drilling at 25' streaks of red/brown silty fine sand with rock fragments	

Logged By: W. H. Gibson

Borehole Log

NFE Technologies, Inc.
250 Dominion Dr., Morrisville, NC 27560
Ph: 919-469-4800 Fx: 919-319-8400

City of Durham Landfill
Piezometer Installation
East Club Blvd.
Durham, NC

JOB NO.: 03-271
LOG OF: P-2R
Sheet 2 OF 2

Recovery	Blow Counts			Depth (ft.)	Graphic Log	Materials Description	Well Construction
						streaks of red/brown silty fine sand with rock fragments	Silica Sand Filter Pack; 2" Sch 40 PVC 0.010 Slot Screen
						Auger refusal 32'	
				33			
				38			
				43			
				48			
				53			

Logged By: W. H. Gibson

BAIN, PALMER & ASSOCIATES, INC.
Environmental Consultants

Client Durham Landfill — Boring No. P-3
Project Durham Landfill — Driller Trigon Engineering
Total Depth 39.0 ft. — Elevation 347.62 — Boring Type & Size 4.25 in. ID/HSA
Date Started 12-17-93 — Date Ended 12-18-93 — Logged By James M. Allen
Depth to Water 28.61 ft. — Date Measured 3-31-94 — Water Level Elevation 319.01

DEPTH (FEET)	ELEVATION FT AMSL	BLOWS PER 6 IN.	PERCENT RECOVERY	UNIFIED CLASS.	LITHOLOGIC DESCRIPTION	REMARKS
2	346					
4	344	10 15 17 26	92	ML	SILT with some VERY FINE SAND, hard, orange tan, micaceous, dry.	
6	342					
8	340					
10	338	19 32 40 50/3	86	ML	SILT with some VERY FINE SAND, hard, burgundy brown, micaceous, dry.	
12	336					
14	334	22 50/6	83	ML	Same as above.	
16	332					
18	330					
20	328	26 37 19 50/2	100	ML	Same as above.	

BAIN, PALMER & ASSOCIATES, INC.
Environmental Consultants

Client Durham Landfill — Boring No. P-3
Project Durham Landfill — Driller Trigon Engineering
Total Depth 39.0 ft. — Elevation 347.62 — Boring Type & Size 4.25 in. ID/HSA
Date Started 12-17-93 — Date Ended 12-18-93 — Logged By James M. Allen
Depth to Water 28.61 ft. — Date Measured 3-31-94 — Water Level Elevation 319.01

DEPTH (FEET)	ELEVATION FT AMSL	BLOWS PER 6 IN.	PERCENT RECOVERY	UNIFIED CLASS.	LITHOLOGIC DESCRIPTION	REMARKS
22	326					
24	324	50/4	50	ML	SILT with some VERY FINE SAND, hard, burgundy brown, micaceous, dry.	
26	322					
28	320	50/3	67	ML	Same as above.	
30	318					
32	316					
34	314	50/5	60	ML	Same as above, green weathering.	
36	312					
38	310	50/3	67	ML	Same as above, reddish brown-to-maroon.	
40	308					Boring Terminated at 39.0 ft.

Borehole Log

NFE Technologies, Inc.
250 Dominion Dr., Morrisville, NC 27560
Ph: 919-469-4800 Fx: 919-319-8400

City of Durham Landfill
Piezometer Installation
East Club Blvd.
Durham, NC

JOB NO.: 03-271
LOG OF: P-4R
Sheet 1 OF 2

DRILLER: Marty Shaver
DATE DRILLED: 6/8/2004
DRILL METHOD: 4.25 ID HSA

GROUND SURFACE ELEVATION: ft.
TOP OF CASING ELEVATION: ft.
WATER LEVEL: 25.02 ft. bls Date: 6/10/2004

Recovery	Blow Counts			Depth (ft.)	Graphic Log	Materials Description	Well Construction
				5		brown silty sand	Cement grout; 2" Sch 40 PVC
				10		red/brown silt	
				15			Bentonite Seal
				20		red/brown silt with siltstone fragments	Silica Sand Filter Pack
				25			

Logged By: W. H. Gibson

Borehole Log

NFE Technologies, Inc.
250 Dominion Dr., Morrisville, NC 27560
Ph: 919-469-4800 Fx: 919-319-8400

City of Durham Landfill
Piezometer Installation
East Club Blvd.
Durham, NC

JOB NO.: 03-271
LOG OF: P-4R
Sheet 2 OF 2

Recovery	Blow Counts			Depth (ft.)	Graphic Log	Materials Description	Well Construction
				33		red/brown silt with siltstone fragments	Silica Sand Filter Pack; 2" Sch 40 PVC 0.010 Slot Screen
						borehole terminated at 35'	
						gray/red siltstone	
				38			
				43			
				48			
				53			

Logged By: W. H. Gibson

BAIN, PALMER & ASSOCIATES, INC.
Environmental Consultants

Client Durham Landfill — Boring No. P-6
Project Durham Landfill — Driller Trigon Engineering
Total Depth 59.0 ft. — Elevation 348.44 — Boring Type & Size 6.25 in. HSA/5.88 in. TC
Date Started 2-21-94 — Date Ended 3-8-94 — Logged By Julia I. Almy
Depth to Water 40.08 ft. — Date Measured 4-4-94 — Water Level Elevation 308.36

DEPTH (FEET)	ELEVATION FT AMSL	BLOWS PER 6 IN.	PERCENT RECOVERY	UNIFIED CLASS.	LITHOLOGIC DESCRIPTION	REMARKS
	347	0 1 2 3	58	SM MH	0.0-1.0 ft. FINE to MEDIUM GRAINED SAND, organic matter 1.0-2.0 ft. SILT and CLAY with a trace of FINE SAND, soft, micaceous, mottled orange and yellow with relict structure, moist	1 blow for 12 in.
2						
	345					
4						
	343	5 11 13 23	83	SM ML	5.0-5.8 ft same as 1.0 - 2.0 ft above. 5.8 - 7.0 ft SILT and FINE SAND with a trace of CLAY, stiff mottled dark red and grey, crumbles easily, dry.	
6						
	341					
8						
	339					
10						
	337	15 40 50/4	100	ML	SILT and FINE SAND, stiff to hard, dark red and gray, dry	
12						
	335					
14						
	333	25 50/4	100	ML	SILT and FINE SAND, micaceous, gray, black, dark red. Weathered shale? Sandstone/Granite?	
16						
	331					
18						
	329					
20						

BAIN, PALMER & ASSOCIATES, INC.
Environmental Consultants

Client Durham Landfill — Boring No. P-6
Project Durham Landfill — Driller Trigon Engineering
Total Depth 59.0 ft. — Elevation 348.44 — Boring Type & Size 6.25 in. HSA/5.88 in. TC
Date Started 2-21-94 — Date Ended 3-8-94 — Logged By Julia I. Almy
Depth to Water 40.08 ft. — Date Measured 4-4-94 — Water Level Elevation 308.36

DEPTH (FEET)	ELEVATION FT AMSL	BLOWS PER 6 IN.	PERCENT RECOVERY	UNIFIED CLASS.	LITHOLOGIC DESCRIPTION	REMARKS
	327	30 50/3	100		Same as above, partially weathered rock	
22						
	325					
24						
	323	50/5	100		Same as above, partially weathered rock, dark blue-gray, shaly, dry.	
26						
	321					
28						
	319					
30		50/4	100		Same as above, dark red with mica	
	317					
32						
	315					
34						
	313	50/3	100		Weathered shale? Dark red, micaceous.	
36						
	311					
38						
	309					
40						

BAIN, PALMER & ASSOCIATES, INC.
Environmental Consultants

Client Durham Landfill — Boring No. P-6
Project Durham Landfill — Driller Trigon Engineering
Total Depth 59.0 ft. — Elevation 348.44 — Boring Type & Size 6.25 in. HSA/5.88 in. TC
Date Started 2-21-94 — Date Ended 3-8-94 — Logged By Julia I. Almy
Depth to Water 40.08 ft. — Date Measured 4-4-94 — Water Level Elevation 308.36

DEPTH (FEET)	ELEVATION FT AMSL	BLOWS PER 6 IN.	PERCENT RECOVERY	UNIFIED CLASS.	LITHOLOGIC DESCRIPTION	REMARKS
	307	50/4	100	SM	FINE to MEDIUM GRAINED SAND and SILT, weathered Sandstone, grey, pink, white and black.	
42						
	305					
44						
	303	50/1	100		Weathered Sandstone? (Blue-gray, coarse grained sand with mica)	
46						
	301					
48						
	299					
50		50/0	0		No Recovery	
	297					Lost Hole at 51.5 ft. Redrilled approx. 50ft NW. Drilled and set well at 59.0 ft.
52						
	295					
54						
	293					
56						
	291					
58						
	289					Terminated boring at 59.0 ft.
60						

WELL COMPLETION RECORD

COMPLETE ALL INFORMATION REQUESTED BELOW FOR EACH WELL INSTALLED, AND RETURN FORM TO THE N.C. SOLID WASTE SECTION BOX 27687 RALEIGH, N.C. 27611

NAME OF SITE: Durham Landfill - MW-2	PERMIT NO.: 32-01
ADDRESS: East Club Blvd., State Rt. 1669, Durham, NC	OWNER (print): City of Durham
DRILLING CONTRACTOR: Law Engineering	REGISTRATION NO.: 1387

Casing Type:	SCH 40 PVC			dia.	2	in.	Grout Depth:	from	0	to	6	ft.-dia	in.
Casing Depth:	from	0	to	8	ft.dia.	2	in.	Bentonite Seal:	from	6	to	7	ft.-dia 6 in.
Screen Type:	SCH 40 PVC			dia.	2	in.	Sand PK:	from	7	to	20	ft.-dia	6 in.
Screen Depth:	from	8	to	18	ft.dia	2	in.	Total Well Depth:	from	0	to	20	ft.-dia 6 in.

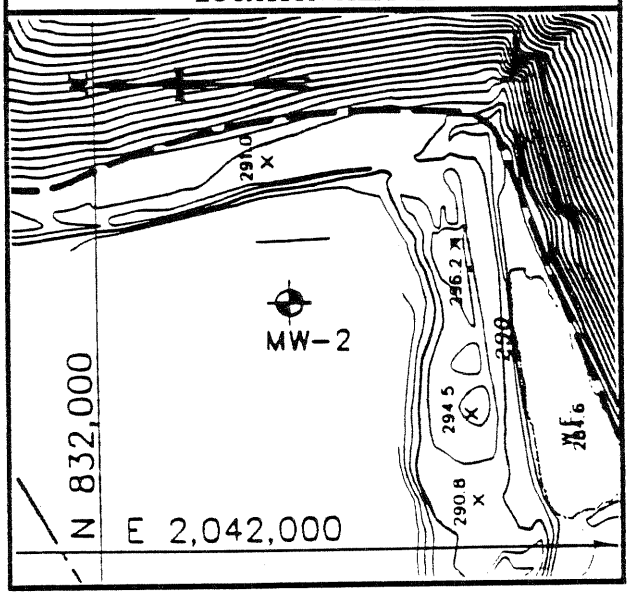
Static Water Level: 10.0 feet from top of casing Date Measured: 4/19/85

Yield (gpm): N/A Method of Testing: N/A Casing is 2 feet above land surface

DRILLING LOG

DEPTH FROM	TO	FORMATION DESCRIPTION
Samples Not Obtained		

LOCATION SKETCH



REMARKS: Information extracted from earlier well completion records by others, previously submitted to former DEM 4-23-85, formerly DL-2

SIGNATURE: DATE: June 15, 1995

WELL COMPLETION RECORD

COMPLETE ALL INFORMATION REQUESTED BELOW FOR EACH WELL INSTALLED, AND RETURN FORM TO THE N.C. SOLID WASTE SECTION BOX 27687 RALEIGH, N.C. 27611

NAME OF SITE: Durham Landfill - MW-3	PERMIT NO.: 32-01
ADDRESS: East Club Blvd., State Rt. 1669, Durham, N.C.	OWNER (print): City of Durham
DRILLING CONTRACTOR: Froehling & Robertson	REGISTRATION NO.: 1387

Casing Type:	SCH 40 PVC			dia.	2	in.	Grout Depth:	from	0	to	6	ft.-dia	in.
Casing Depth:	from	0	to	13	ft.dia.	2	in.	Bentonite Seal:	from	6	to	8	ft.-dia 6 in.
Screen Type:	SCH 40 PVC				dia.	2	in.	Sand PK:	from	8	to	25	ft.-dia 6 in.
Screen Depth:	from	13	to	23	ft.dia	2	in.	Total Well Depth:	from	0	to	25	ft.-dia 6 in.

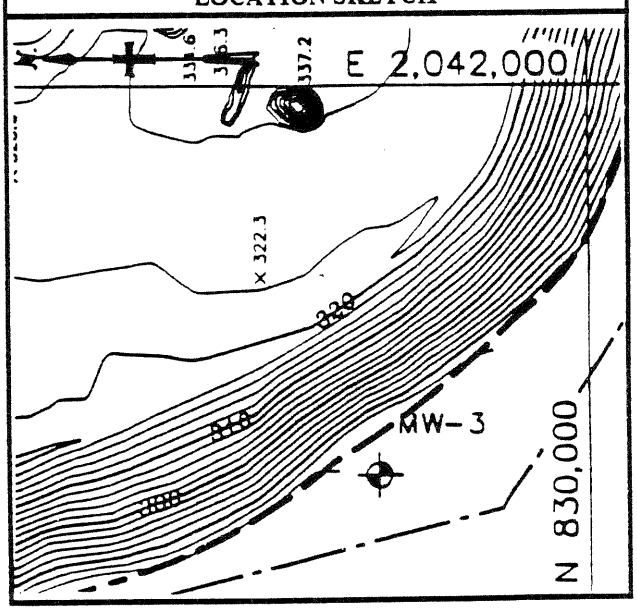
Static Water Level: 8'-4" feet from top of casing Date Measured: 11/9/88

Yield (gpm): N/A Method of Testing: N/A Casing is 2 feet above land surface

DRILLING LOG

DEPTH FROM	DEPTH TO	FORMATION DESCRIPTION
0'	.5'	Topsoil
.5'	2'	Tan silty sand (SM)
2'	6.5'	Gray silty sand (CH)
6.5'	8'	Gray & Tan silty clay (CL)
8'	11'	Silty, sandy clay (CL-SC)
11'	16'	Silty fine to medium sand (SM)
16'	25'	Silty sand - Triassic sandstone

LOCATION SKETCH



REMARKS: Information extracted from earlier well completion record submitted to former DEM 11-8-88

SIGNATURE: DATE: June 15, 1995

BORING LOG

SINCE 1881

FROEHLING & ROBERTSON, INC.
FULL SERVICE LABORATORIES • ENGINEERS & CHEMISTS
"OVER ONE HUNDRED YEARS OF SERVICE"

Report No. P-66-313 DATE 11-9-88

Client: City of Durham, Durham, NC

Project: Landfill Site, 2115 E. Club Boulevard, Durham, NC

Boring No. MW-3 | Total Depth 25.0 ft. | Elevation: | Location:

Type of Boring 3.25" I.D. HSA | Started: 11-9-88 | Completed: 11-9-88 | Driller: W. Dew

Elevation	Depth	DESCRIPTION OF MATERIALS (Classification)	Sample Blows	Sample Depth (Feet)	N	Sample No.	REMARKS
	0.0'						
	0.5'	Brown fibrous topsoil.	WOT				
		Loose, tan silty SAND (alluvium). (SM)	1 2	1.5	3	S-1	GROUNDWATER DATA
	2.0'			2.0			6 ft. at 24 hours
		Soft, gray silty CLAY. (CH)	3 1 2	3.5	3	S-2	
			1 2 2	5.0	4	S-3	WOT = Weight of Tools
	6.5			6.0			
		Firm, light gray and tan silty CLAY. (CL)	3 4 4	7.5	8	S-4	
	8.0'			8.5	-		
		Stiff, light gray and tan silty sandy CLAY. (CL-SC)	4 6 5	10.0	11	S-5	
	11.0'						
		Medium dense, brown silty fine to medium SAND. (SM)		13.5			
			5 5 4	15.0	9	S-6	
	16.0'						
		Very dense, light gray silty SAND - Triassic sandstone.					
			50	18.5 18.6	50/1"	S-7	
			50	23.5 23.6	50/1"	S-8	
	25.0'						
		Boring terminated at 25.0 feet.					

MALCOLM PIRNIE

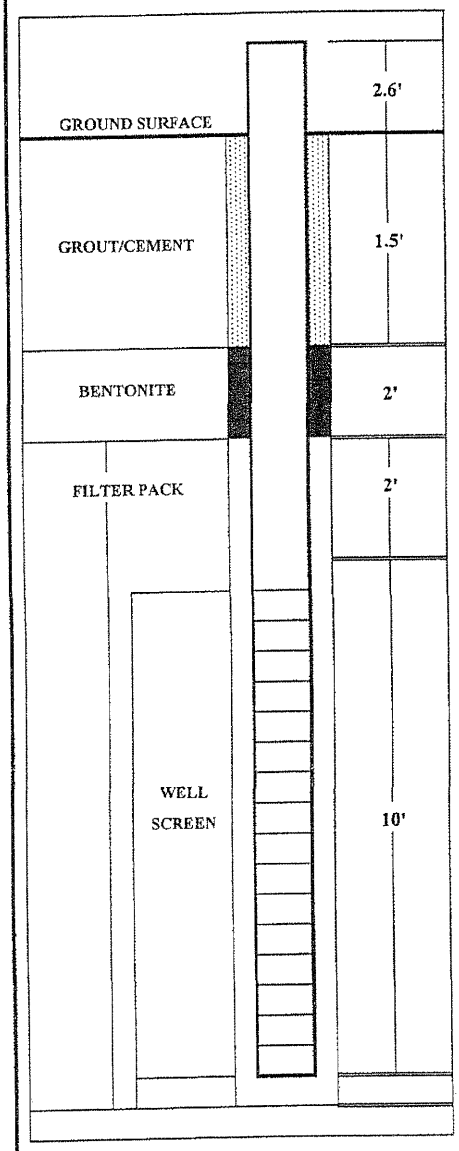
WELL ID: MW-4R

BORING ID: MW-4R

Malcolm Pirnie Inc. 11832 Rock Landing Drive Suite 400 Newport News, VA 23606 757-873-8700 FAX: 757-873-8723

PROJECT NAME:	City of Durham Municipal Landfill	PROJECT NO:	0759-050	ELEVATION (Ft. MSL)	
LOCATION:	Durham, North Carolina			GROUND:	292.68
NORTHING:	829621.66	DRILLING INFORMATION		WELL:	295.28
EASTING:	2042326.66	COMPANY:	Fishburne Drilling Inc.	CASING:	N\A

INSTALLATION	DATE	TIME				
STARTED:	6/30/99	1120	DRILLER:	Gerald Wilhelm	FLUIDS:	None
COMPLETED:	6/30/99	1530	EQUIPMENT:	CME 75	BORE HOLE DIAMETER:	9"
MPI PERSONNEL:			METHOD:	Hollow Stem Augers	SAMPLE INTERVAL:	Continuous
			EQUIPMENT DECON.:	Steam Cleaned	SAMPLE METHOD:	SPT



WELL CONSTRUCTION DATA

PROTECTIVE CASING:

Locking Cap (Y/N): Y *Protective Posts (#):* 0

Protective outer casing: Steel casing

Pad: 2' x 2' formed concrete

WELL MATERIALS:

Screen

Type: Schedule 40 PVC

Diameter 2" *Slot Type:* Machined *Slot Size:* 0.010"

Joint: Flush Thread *Length:* 10'

Riser

Type: Schedule 40 PVC

Diameter 2" *Length:* 8.1'

TOTAL DEPTH OF WELL: 15.5' below ground surface

INITIAL WATER LEVEL: 1.2' below ground surface

FILTER PACK:

Material: #2 Well Gravel

Amount used: 400 lbs

Total thickness: 12.5'

BENTONITE:

Type: Hole Plug

Size: 3/8"

Amount used: 40 lbs

GROUT:

Type: 5% Cement Bentonite

Amount used: 10 gallons

WELL DEVELOPMENT

Method: Bailer

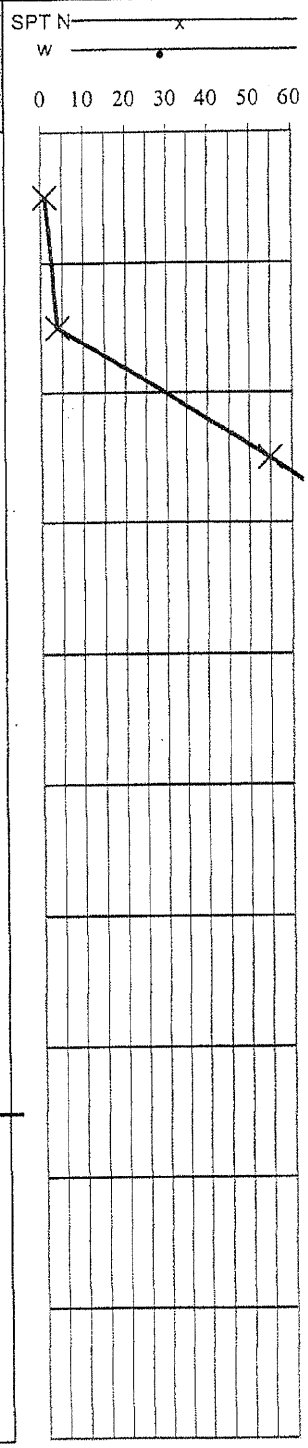
Development Time: 1.5 hours

NOTES: Initial water level reading recorded on July 6, 1999.

MALCOLM PIRNIE

Project:	City of Durham Landfill	**Borehole:**	MW-4R
	MW-4 Replacement Well	**Project Number:**	0759-050
Date:	June 30, 1999	**Drilling Contractor:**	Fishburne Drilling
Location:	Durham, North Carolina	**Driller:**	Gerald Wilhelm
Inspector:	William J. Friedmann	**Drilling Equipment:**	CME 75, hollow stem augers.
Elevation:	295.28 ft MSL (TOC)		

Scale	SAMPLE DETAIL Type	No.	Blows	Depth	Rec.	STRATIGRAPHIC LOG
1' 2'	SPT	1	1 1 0 1	0-2'	4"	Silty clay with sand, 10YR 4/2 (dark grayish brown), moist, sticky, cohesive.
3' 4'	SPT	2	1 2 2 2	2-4'	12"	Top 4"- Same as above. Bottom 8"- medium sand with some fine sand and silt, 2.5Y6/4 (light yellowish brown) with 2.5Y6/8 (olive yellow) mottles, saturated.
5' 6'	SPT	3	2 16 39 50	4-6'	12"	Same as above, becoming more cohesive, weathered sandstone, friable.
7' 8'	SPT	4	50/2"	6-8'	2"	Weathered sandstone, color change to 2.5Y6/6, (olive yellow) mica flakes more visible, moist.
9' 10'	SPT	5	50/6"	8-10'	6"	Weathered sandstone, 10GY7/1 (light greenish gray) to 2.5YR8/3 (pink), friable under hand pressure.
11' 12'	SPT	6	45 50 100	10-12'	3"	Same as above, slightly moist, 10GY6/1 (greenish gray) becoming slightly more green, sand grains are medium.
13' 14'	SPT	7	50/3"	12-14'	3"	Same as above, dry.
15'	SPT	8	50/5"	14-16'	5"	Same as above, dry, friable.
16' 17' 18' 19' 20'						Boring terminated at 15.5' below ground surface.



NOTES: Initial water level 1.2' below ground surface.

RECORD OF SOIL EXPLORATION (BORING LOG)

Client: Malcolm Pirnie, Inc./ City of Durham — Boring No. MW-5
Project Name: Durham Landfill Closure Plan Phase II — Project No. 94NCP270
Site Location: 2115 East Club Blvd. at Camden Avenue — County & State Durham, NC
Boring Location(Sta.) As per plan — Offset As per plan — Alignment As per plan
Inspector: Bo Dodson — Date Started: 08.17.94 — Date Completed: 08.17.94
Collar Elevation _____ — Drill Machine ATV Rig — Drill Method: Hollow Stem Auger
Total Depth: 20.0 feet — Ground Water at: 0 Hr. 16.0 feet — at 24 Hr. 5.2 feet
Hammer Weight: 140 lbs. — Hammer Drop: 30" — Sampler Type: Split Spoon

Elev.	Depth Ft.	Blow Count 6"	6"	6"	Blows Per Foot (0 25 50 75 100)	sample no.	Recovery in 18"	GW	Log	Soil & Rock Description
		7	9	16		1	9IN			TOP SOIL 2.5' SAND,CLAY,SILT
										GRAY SANDSTONE 3
		13	7	7		2	8IN			BROWN WELL GRADED SAND, SILT AND CLAY FILL MATERIAL 7.3 FT
	--5							▼		
		4	7	7		3	8IN			
		50/.5	-	-		4	8IN			TAN AND GRAY SILTY CLAYEY FINE SAND RESIDUALS 11.5 FT
	--10									
		50/.4	-	-		5	8IN			GRAY AND TAN SANDSTONE 16 FT
	--15									
										DENSE GRAY SILT AND SOME FINE SAND 20 FT
	--20									
	--25									

ANDFILL.MW5

WELL COMPLETION RECORD

COMPLETE ALL INFORMATION REQUESTED BELOW FOR EACH WELL INSTALLED, AND RETURN FORM TO THE N.C. SOLID WASTE SECTION BOX 27687 RALEIGH, N.C. 27611

NAME OF SITE: Durham Landfill - MW-5	PERMIT NO.: 32-01
ADDRESS: East Club Blvd., State Rt. 1669, Durham, N.C.	OWNER (r int): City of Durham
DRILLING CONTRACTOR: NFE Technologies, Inc.	REGISTRATION NO.: 1387

Casing Tyre:	SCH 40 PVC			dia.	2	in.	G out Derth:	from	2.5	to	9	ft.-dia	7.25 in.
Casing Derth:	from	0	to	10	ft.dia.	2 in.	Bentonite Seal:	from	9	to	10	ft.-dia	7.25 in.
Sc een Tyre:	SCH 40 PVC			dia.	2	in.	Sand PK:	from	10	to	20	ft.-dia	7.25 in.
Sc een Derth:	from	10	to	20	ft.dia	2 in.	Total Well Derth:	from	0	to	20	ft.-dia	7.25 in.

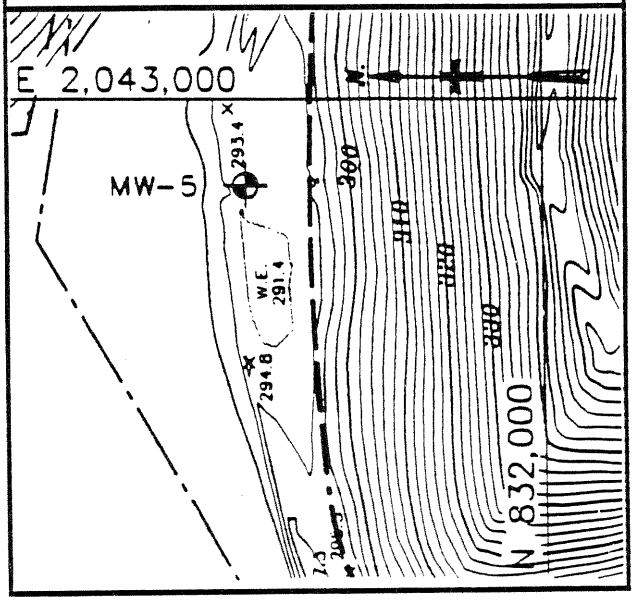
Static Wate Level: 7.2 feet from top of casing Date Measu ed: 8/17/94

Yield (grm): N/A Method of Testing: N/A Casing is 2 feet above land surface

DRILLING LOG

DEPTH FROM	DEPTH TO	FORMATION DESCRIPTION
0'	2.5'	Topsoil, clay, sand, silt
2.5'	3.0'	Gray Sandstone
3.0'	7.3'	Brown, well-graded, sand, silt, and clay. Fill material.
7.3'	11.5'	Tan and gray silty clayey fine sand residuals
11.5'	16.0'	Gray/tan sandstone
16.0'	20.0'	Dense gray silt and some fine sand

LOCATION SKETCH



REMARKS: 6" concrete pad at surface over additional bentonite seal to 2.5' depth.

SIGNATURE: DATE: June 15, 1995

Borehole Log

NFE Technologies, Inc.
250 Dominion Dr., Morrisville, NC 27560
Ph: 919-469-4800 Fx: 919-319-8400

City of Durham Landfill
Piezometer Installation
East Club Blvd.
Durham, NC

JOB NO.: 03-271
LOG OF: MW-6R
Sheet 1 OF 1

DRILLER: Marty Shaver
DATE DRILLED: 6/8/2004
DRILL METHOD: 4.25 ID HSA

GROUND SURFACE ELEVATION: ft.
TOP OF CASING ELEVATION: ft.
WATER LEVEL: 9.8 ft. bls Date: 6/10/2004

Recovery	Blow Counts			Depth (ft.)	Graphic Log	Materials Description
						brown sandy clay
				5		gray/brown clay with silt/fine sand
				10		
				15		yellow/brown clay
						gray silty sand
				20		gray silty sand, rock fragments
						24' - borehole terminated
				25		

Well Construction

10' screen

Logged By: W. H. Gibson

Borehole Log

NFE Technologies, Inc.
250 Dominion Dr., Morrisville, NC 27560
Ph: 919-469-4800 Fx: 919-319-8400

City of Durham Landfill
Piezometer Installation
East Club Blvd.
Durham, NC

JOB NO.: 03-271
LOG OF: MW-7R
Sheet 1 OF 2

DRILLER: Marty Shaver
DATE DRILLED: 6/9-10/2004
DRILL METHOD: 4.25 ID HSA / 6" air hammer

GROUND SURFACE ELEVATION: _____ ft.
TOP OF CASING ELEVATION: _____ ft.
WATER LEVEL: 15.51 ft. bls Date: 6/10/2004

Recovery	Blow Counts			Depth (ft.)	Graphic Log	Materials Description	Well Construction
				5, 10, 15, 20, 25		yellow/brown silty sand	Cement grout; 2" Sch 40 PVC
						brown silt	Bentonite Seal
						light brown silt	
						light brown sand, rock fragments	Silica Sand Filter Pack
						gray/brown sand, rock fragments dry started air-hammer at 19'	2" Sch 40 PVC 0.010 Slot Screen
						water at 21', fracture ? light brown silty sand	
						gray sand with silt	

Logged By: W. H. Gibson

Borehole Log

NFE Technologies, Inc.
250 Dominion Dr., Morrisville, NC 27560
Ph: 919-469-4800 Fx: 919-319-8400

City of Durham Landfill
Piezometer Installation
East Club Blvd.
Durham, NC

JOB NO.: 03-271
LOG OF: MW-7R
Sheet 2 OF 2

Recovery	Blow Counts			Depth (ft.)	Graphic Log	Materials Description	Well Construction
						gray sand with silt	
				33		gray fine sand	Silica Sand Filter Pack
				38			2" Sch 40 PVC 0.010 Slot Screen
						borehole terminated at 41'	
				43			
				48			
				53			

25' screen

X!

Logged By: W. H. Gibson

WELL COMPLETION RECORD

COMPLETE ALL INFORMATION REQUESTED BELOW FOR EACH WELL INSTALLED, AND RETURN FORM TO THE N.C. SOLID WASTE SECTION BOX 27687 RALEIGH, N.C. 27611

NAME OF SITE: Durham Landfill - MW-7	PERMIT NO.: 32-01
ADDRESS: East Club Blvd., State Rt. 1669, Durham, N.C.	OWNER (r int): City of Durham
DRILLING CONTRACTOR: NFE Technologies Inc.	REGISTRATION NO.: 1387

Casing Tyre:	SCH 40 PVC			dia.	2	in.	G out Derth:	from 2.5	to 18	ft.-dia	7.25 in.
Casing Derth:	from 0	to	29	ft.dia.	2	in.	Bentonite Seal:	from 18	to 19	ft.-dia	7.25 in.
Sc een Tyre:	SCH 40 PVC			dia.	2	in.	Sand PK:	from 19	to 29	ft.-dia	7.25 in.
Sc een Derth:	from 19	to	29	ft.dia	2	in.	Total Well Derth:	from 0	to 29	ft.-dia	7.25 in.

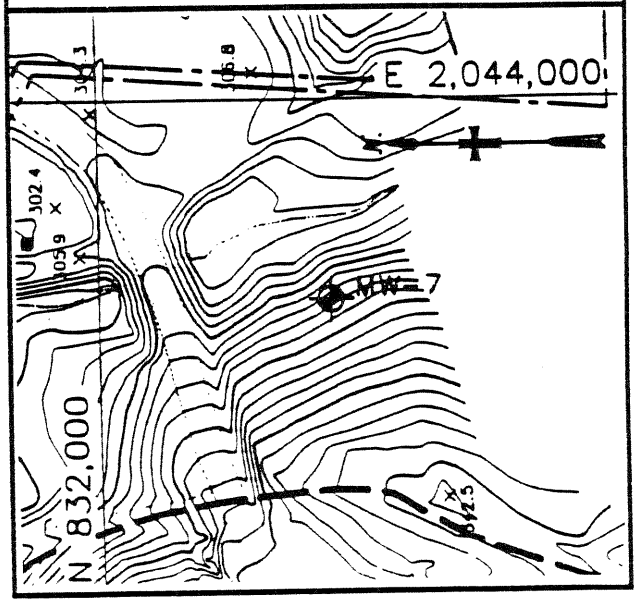
Static Wate Level: 14 feet from top of casing Date Measu ed: 9/17/94

Yield (grm): N/A Method of Testing: N/A Casing is 2 feet above land surface

DRILLING LOG

DEPTH FROM	DEPTH TO	FORMATION DESCRIPTION
0'	.5'	Topsoil
.5'	7.8'	Fine, sandy, silty clay
7.8'	11.4'	Gray silty, fine sand
11.4'	29'	Brown clayey fine sand.
		(sandstone)

LOCATION SKETCH



REMARKS: Concrete pad at surface over additional bentonite seal 0.5' to 2.5' depth.

SIGNATURE: DATE: June 15, 1995

WELL COMPLETION RECORD

COMPLETE ALL INFORMATION REQUESTED BELOW FOR EACH WELL INSTALLED, AND RETURN FORM TO THE N.C. SOLID WASTE SECTION BOX 27687 RALEIGH, N.C. 27611

NAME OF SITE: Durham Landfill - MW-8	PERMIT NO.: 32-01
ADDRESS: East Club Blvd., State Rt. 1669, Durham, N.C.	OWNER (r int): City of Durham
DRILLING CONTRACTOR: NFE Technologies	REGISTRATION NO.: 1387

Casing Tyre:	SCH 40 PVC			dia.	2	in.	G out Derth:	from 1.5	to 5	ft.-dia	7.25 in.
Casing Derth:	from 0	to	6	ft.dia.	2	in.	Bentonite Seal:	from 5	to 6	ft.-dia	7.25 in.
Sc een Tyre:	SCH 40 PVC			dia.	2	in.	Sand PK:	from 6	to 13.5	ft.-dia	7.25 in.
Sc een Derth:	from 6	to	13.5	ft.dia	2	in.	Total Well Derth:	from 0	to 13.5	ft.-dia	7.25 in.

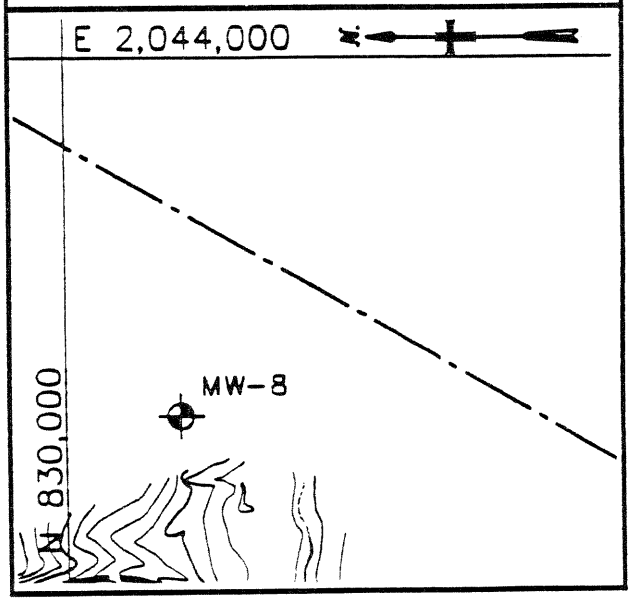
Static Wate Level: 6.5 feet from top of casing Date Measu ed: 9/18/94

Yield (grm): N/A Method of Testing: N/A Casing is 2 feet above land surface

DRILLING LOG

DEPTH FROM	DEPTH TO	FORMATION DESCRIPTION
0'	0.5'	Topsoil
0.5'	7.3'	Multi-colored fine sand, silt, clay, mix
7.3'	13.5'	Brown gray, fine, sandy silt

LOCATION SKETCH



REMARKS: 6' concrete pad at surface over additional bentonite seal to 1.5' depth.

SIGNATURE: _____ DATE: June 15, 1995

NFE TECHNOLOGIES, INC.
P.O. Box 374 • Cary, North Carolina 27512-0374 • (919) 851-9000

RECORD OF SOIL EXPLORATION (BORING LOG)

Client: Malcolm Pirnie, Inc./ City of Durham — Boring No. MW-8
Project Name: Durham Landfill Closure Plan Phase II — Project No. 94NCP340
Site Location: 2115 East Club Blvd. at Camden Avenue — County & State Durham, NC
Boring Location(Sta.) As per plan — Offset As per plan — Alignment As per plan
Inspector: Bo Dodson — Date Started: 09.18.94 — Date Completed: 09.18.94
Collar Elevation _____ — Drill Machine ATV Rig — Drill Method: Hollow Stem Auger
Total Depth: 13.5 feet — Ground Water at: 0 Hr. 6.5 feet — at 24 Hr. 6.5 feet
Hammer Weight: 140 lbs. — Hammer Drop: 30" — Sampler Type: Split Spoon

Elev.	Depth Ft.	Blow Count 6"	6"	6"	Blows Per Foot (0 25 50 75 100)	sample no.	Recovery in 18"	GW	Log	Soil & Rock Description
	-	08	12	13		01	12"			--TOP SOIL--
	-									MULTI COLORED FINE SAND, SILT CLAY MIX
	-	08	11	12		02	12"			
	--5									
	-							▼		
	-									7.3 FT
	-	33	50	50/0		03	07"			BROWN GRAY FINE SANDY SILT
	--10									
	-									13.5 FT
	-	50/0				04	0"			BOTTOM OF HOLE: 13.5 FT
	--15									
	--20									
	--25									

Borehole Log

NFE Technologies, Inc.
250 Dominion Dr., Morrisville, NC 27560
Ph: 919-469-4800 Fx: 919-319-8400

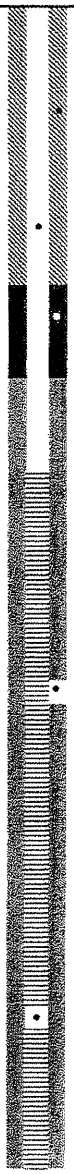
City of Durham Landfill
Piezometer Installation
East Club Blvd.
Durham, NC

JOB NO.: 03-271
LOG OF: MW-9R
Sheet 1 OF 1

DRILLER: Marty Shaver
DATE DRILLED: 6/8/2004
DRILL METHOD: 4.25 ID HSA

GROUND SURFACE ELEVATION: ft.
TOP OF CASING ELEVATION: ft.
WATER LEVEL: 14.25 ft. bls Date: 6/10/2004

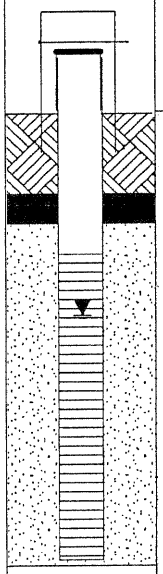
Recovery	Blow Counts			Depth (ft.)	Graphic Log	Materials Description	Well Construction
				5		orange silty clay	Cement grout; 2" Sch 40 PVC; Bentonite Seal
				10			
				15			Silica Sand Filter Pack
						brown silty clay	
				20		red/brown silty clay	2" Sch 40 PVC 0.010 Slot Screen
						yellow silty clay	
				25		25' - borehole terminated	



Logged By: W. H. Gibson

COMPLETION REPORT OF SOIL BORING NO. MW-10

PROJECT:	City of Durham MSW Landfill	APPROXIMATE ELEVATION:	284.00
PROJECT NO:	1054-07-469	BORING DEPTH (FT.):	14.8
PROJECT LOCATION:	Durham, North Carolina	LOGGED BY:	SDL
DRILLING CONTRACTOR:	S&ME		
DRILLING METHOD:	4¼" H.S.A.		
DATE DRILLED:	8/20/2008		

STRATA DESCRIPTION	SYMBOL	DEPTH (feet)	WELL DETAILS	DEPTH (feet)	LEGEND	SPT (N-value)	ELEVATION (feet)	FID (ppm)	PID (ppm)	WELL CONSTRUCTION DETAILS
Ground Surface							284.00			PROTECTIVE CASING Diameter: Type: Interval:
Slightly silty SAND - SAND		0.0								
Sandy silty CLAY w/ silty CLAY layers, moist @ 3.5'				2.61 3.61	TOC CG BS		279.00			OUTER CASING Diameter: Type: Length:
Very slightly clayey silty SAND, moist		5.0								
SAND, wet										RISER CASING Diameter: Type: Interval:
Slightly clayey silty SAND, moist							274.00			
Very slightly clayey silty SAND		10.0								GROUT Type: **cement** Interval: **0 -2.61**
Very slightly silty SAND to SAND w/ weathered rock - partially weathered rock				14.61 14.8	FP BSC TD					SEAL Type: **bentonite** Interval: **2.61 -3.61**
Boring terminated at 14.8' bgs, well set at 14.61' bgs										FILTERPACK Type: **#2 sand** Interval: **3.61 - 14.8**
										SCREEN Diameter: **2"** Type: **Sch 40 pvc** Interval: **4.61 - 14.61**

LEGEND

- ▽ = Water Level At Termination of Boring (TOB)
- ▼ = Water Level After 24 Hours
- BS = Bentonite Seal
- FP = Filter Pack
- CG = Cement Grout
- BSC = Bottom of Screen
- REC = Core Recovery
- RQD = Rock Quality Designation

NOTES: Ground surface elevation is 282.11

S&ME
ENGINEERING • TESTING
ENVIRONMENTAL SERVICES
3201 Spring Forest Road
Raleigh, NC 27616

COMPLETION REPORT OF WELL NO. MW-10

NON RESIDENTIAL WELL CONSTRUCTION RECORD

North Carolina Department of Environment and Natural Resources- Division of Water Quality

WELL CONTRACTOR CERTIFICATION # 2254-A

1. WELL CONTRACTOR:

Seth Low
Well Contractor (Individual) Name

S&ME, Inc.
Well Contractor Company Name

STREET ADDRESS 3201 Spring Forest Road

Raleigh | NC | 27616
City or Town | State | Zip Code

(919) 872-2660
Area code- Phone number

2. WELL INFORMATION:

SITE WELL ID #(if applicable) MW-10

WELL CONSTRUCTION PERMIT#(if applicable) NONE

OTHER ASSOCIATED PERMIT #(if applicable) NONE

3. WELL USE (Check Applicable Box) Monitoring ☒ Municipal/Public ☐ Industrial/Commercial ☐ Agricultural ☐ Recovery ☐ Injection ☐ Irrigation ☐ Other ☐ (list use)

DATE DRILLED August 20 2008

TIME COMPLETED 12:30 AM ☐ PM ☒

4. WELL LOCATION:

CITY: Durham COUNTY Durham

City of Durham - Closed MSW Landfill
(Street Name, Numbers, Community, Subdivision, Lot No., Parcel, Zip Code)

TOPOGRAPHIC / LAND SETTING:
☐ Slope ☐ Valley ☒ Flat ☐ Ridge ☐ Other
(check appropriate box)

LATITUDE N° 36° 01' 58.79"

LONGITUDE W° 78° 51' 37.37

May be in degrees, minutes, seconds or in a decimal format

Latitude/longitude source: ☐ GPS ☒ Topographic map
(location of well must be shown on a USGS topo map and attached to this form if not using GPS)

5. FACILITY- is the name of the business where the well is located.

FACILITY ID #(if applicable) MSW Landfill Permit #32-01

NAME OF FACILITY City of Durham Closed MSWLF

STREET ADDRESS 2115 E Club Blvd.

Durham | NC | 27704
City or Town | State | Zip Code

CONTACT PERSON Nancy Newell, P.E.

MAILING ADDRESS 1600 Mist Lake Drive

Durham | NC | 27704
City or Town | State | Zip Code

(919) 560-4381
Area code - Phone number

6. WELL DETAILS:

a. TOTAL DEPTH: 16.4'

b. DOES WELL REPLACE EXISTING WELL? YES ☐ NO ☒

c. WATER LEVEL Below Top of Casing: 8.4' FT.
(Use "+" if Above Top of Casing)

d. TOP OF CASING IS +3.1' FT. Above Land Surface*
*Top of casing terminated at/or below land surface may require a variance in accordance with 15A NCAC 2C .0118.

e. YIELD (gpm): _____ METHOD OF TEST _____

f. DISINFECTION: Type _____ Amount _____

g. WATER ZONES (depth):

MOIST	From 3.5'	To 5.5'	From	To
WET	From 5.5'	To 8'	From	To
MOIST	From 8'	To 9'	From	To

7. CASING:

Depth		Diameter	Thickness/Weight	Material
From +3.1	To 3.3'	Ft. 2"	SCH 40	PVC
From	To	Ft.		
From	To	Ft.		

8. GROUT:

Depth		Material	Method
From 0.5	To 1.3'	Ft. PORTLAND CEMENT TYPE II	FREE POUR
From	To	Ft.	
From	To	Ft.	

9. SCREEN:

Depth		Diameter	Slot Size	Material
From 3.3'	To 13.3'	Ft. 2" in.	.010 in.	PVC SCH 40
From	To	Ft. in.	in.	
From	To	Ft. in.	in.	

10. SAND/GRAVEL PACK:

Depth		Size	Material
From 2.3'	To 13.3'	Ft. #2	SAND
From 1.3'	To 2.3'	Ft. 3/8	BENTONITE PELLETS
From	To	Ft.	

11. DRILLING LOG

From	To	Formation Description
0.5	1.5'	SCL SISA - SA
1.5'	4'	SA SICL w/ SICL lenses
4'	5.5'	VSL CL SISA
5.5'	8'	SA
8'	9'	SL CL SISA
9'	13.5'	VSL CL SISA
13.5'	14.8'	VSL SISA - SA w/ CLAY PARTS

12. REMARKS:

I DO HEREBY CERTIFY THAT THIS WELL WAS CONSTRUCTED IN ACCORDANCE WITH 15A NCAC 2C, WELL CONSTRUCTION STANDARDS, AND THAT A COPY OF THIS RECORD HAS BEEN PROVIDED TO THE WELL OWNER.

Seth D. Low — 8-20-2008
SIGNATURE OF CERTIFIED WELL CONTRACTOR — DATE

SETH D. LOW
PRINTED NAME OF PERSON CONSTRUCTING THE WELL

Submit the original to the Division of Water Quality within 30 days. Attn: Information Mgt., 1617 Mail Service Center – Raleigh, NC 27699-1617 Phone No. (919) 733-7015 ext 568.

Form GW-1b
Rev.12/07

APPENDIX III

DEDICATED SAMPLING EQUIPMENT SPECIFICATIONS

Click to go to www.geotechenv.com

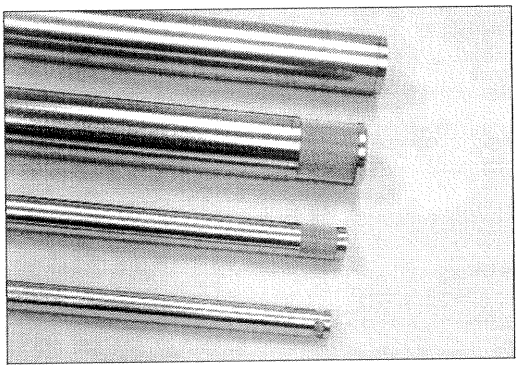
Bladder Pumps, Groundwater Sampling

Geotech Bladder Pump

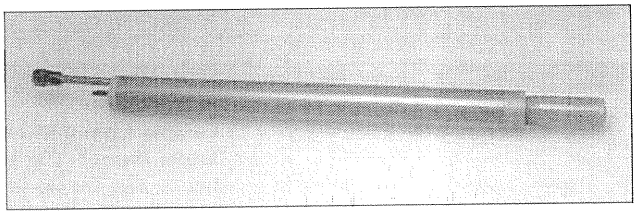
Together with the United States Geological Survey, Geotech designed the original bladder pump and further developed what is known today as the Geotech family of Bladder Pumps. Our design will purge and sample water in wells as small as .75" in diameter, allowing the user to obtain representative samples with minimal agitation.

FEATURES

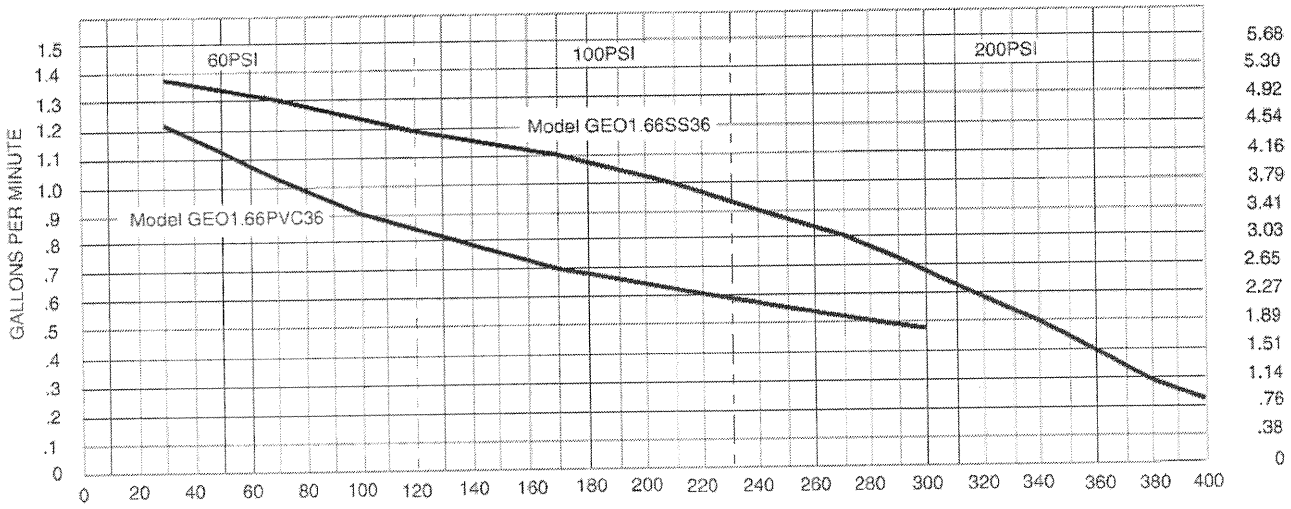
- True low flow capability for more representative samples
- Proprietary long life PTFE bladder
- Constructed of electropolished 316 SS
- Dedicated or portable turnkey systems
- Pumps designed for wells .75" and larger
- Optional screened intake extends bladder life
- Optional Drop Tube Assembly available for sampling from greater depths
- PVC models available
- Limited lifetime warranty (on dedicated SS systems)



Geotech SS Bladder Pumps



Geotech PVC Bladder Pump



Geotech Bladder Pump Performance Curve

Geotech Environmental Equipment, Inc.
2650 East 40th Avenue • Denver, Colorado 80205
(303) 320-4764 • **(800) 833-7958** • FAX (303) 322-7242
email: sales@geotechenv.com website: www.geotechenv.com

Bladder Pumps, Groundwater Sampling

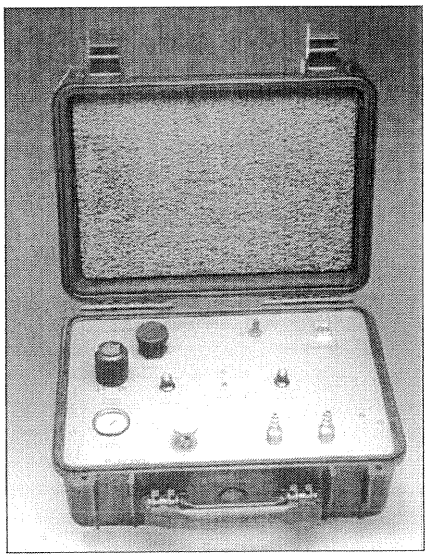
geotech

Geotech Bladder Pump Specifications

	GEO1.66SS36	GEO1.66SS18	GEO1.66PVC36	GEO1.66PVC18	GEO.85SS24	GEO.675SS18
Pump Housing	Electropolished SS, 316	Electropolished SS, 316	PVC	PVC	Electropolished SS, 316	Electropolished SS, 316
Pump Ends	Virgin PTFE	Virgin PTFE	PVC	PVC	Virgin PTFE	Electropolished SS, 316
Bladder Matl.	Virgin PTFE Proprietary resin grade (G303)	Virgin PTFE Proprietary resin grade (G303)	Virgin PTFE Proprietary resin grade (G303)	Virgin PTFE Proprietary resin grade (G303)	Virgin PTFE Proprietary resin grade (G303)	Virgin PTFE Proprietary resin grade (G303)
O.D.	1.66"/4.2cm	1.66"/4.2cm	1.66"/4.2cm	1.66"/4.2cm	.850"/2.2cm	.675"/1.71cm
Length: w/screen	38"/96.5cm	20"/51cm	36"/91.4cm	22"/55.9cm	25"/63.5cm	18"/45.72cm
Weight	5lb/1.9Kg	2.5lb/0.93Kg	3.6lb/1.3Kg	1.8lb/.67Kg	1.6/.60Kg	.83lbs/.38kg
Volume/Cycle	21.1oz./625ml	10.5oz./313ml	13.8oz.408ml	6.9oz./204ml	2.1oz./59.6ml	1.35oz/38.4ml
Max. Flowrate	1.25gpm/4.7lpm	.65gpm/2.4lpm	.97gpm/3.7lpm	.53gpm/2.0lpm	.10gpm/.36lpm	.05gpm/.19lpm
Min. Well I.D.	2"/50mm	2"/50mm	2"/50mm	2"/50mm	1.00"/2.5mm	.75"/1.9mm
Maximum Depth	1000'/305m	1000'/305m	250'/76.25m	250'/76.25m	250'/76.25m	250'/76.25m

GEOCONTROLLER 2 SPECIFICATIONS

The Geocontroller 2 allows you to sample from 0-690 feet with the Geotech Stainless Steel Bladder Pump! The controller is rated for a higher PSI and housed in a waterproof case for field durability and ease of use. The Geocontroller 2 also includes and internal regulator, pressure gauge and ability to use either 12VDC or 115VAC power!



Performance

Operating Depth . . . . . .0-690 feet
Input air pressure . . . . . .up to 300 PSI
On timer range . . . . . .0.25 to 30 seconds*
Off timer range . . . . . .0.25 to 30 seconds*
Timer resolution . . . . . .0.25 seconds
Timer accuracy . . . . . .0.25 seconds
* Custom timer and ranges available

Physical

Enclosure . . . . . .Waterproof 7"x16"x12"
Weight 14lbs

Optional

Built-in 12V battery and charger

CALL GEOTECH TODAY (800) 833-7958

Geotech Environmental Equipment, Inc.
2650 East 40th Avenue • Denver, Colorado 80205
(303) 320-4764 • **(800) 833-7958** • FAX (303) 322-7242
email: sales@geotechenv.com website: www.geotechenv.com

Click to go to www.geotechenv.com

geotech

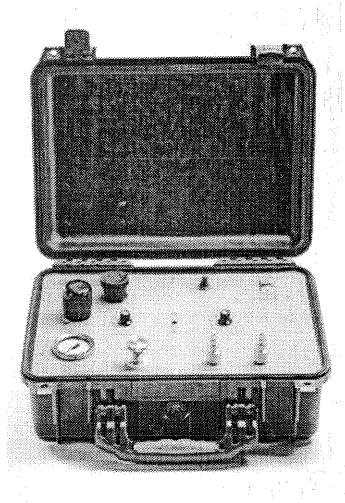
Logic Unit

Geotech Geocontroller 2

Geotech's GEOCONTROLLER 2 utilizes advanced electronic logic to control both high rate purging and gentle low flow sampling. Simple to use, accurate microprocessor controlled on/off timers are utilized to recreate expert techniques for low-flow sampling. The GEOCONTROLLER 2 high-pressure solenoid activated valve delivers even in the deepest sampling applications. The GEOCONTROLLER 2 can be used with any bladder pump system with the use of simple quick-disconnect adapters.

FEATURES

- Microprocessor controlled
- Operates on 115V AC or 12V DC
- Rugged water tight case
- High pressure operation to 300 PSI
- Low flow sampling
- Built in pressure regulator and gauge
- High accuracy timers
- Adjustable fill rate control
- Simple to use
- Designed for trouble free operation
- Includes in line water trap



Geocontroller 2

SPECIFICATIONS

PERFORMANCE

Operating depth	0-690 feet
Input air pressure	up to 300 PSI
On timer range	.125 to 30 seconds*
Off timer range	.125 to 30 seconds*
Timer resolution	.125 seconds
Timer accuracy	.125 seconds

*Custom timer and ranges available

ENVIRONMENTAL

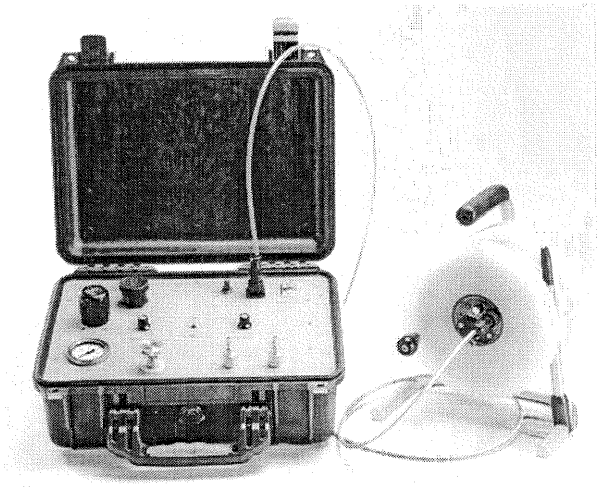
Operating Temperature	0-70°C
Storage Temperature	-20-85°C

PHYSICAL

Enclosure	7 x 16 x 12 inches
Weight	14 pounds

INPUT POWER

Battery	10.5-13.8V DC
AC	105-130V AC
Line Frequency	45-65 Hz
Maximum Power	15 Watts



Geocontroller 2 with optional draw-down control for low flow sampling

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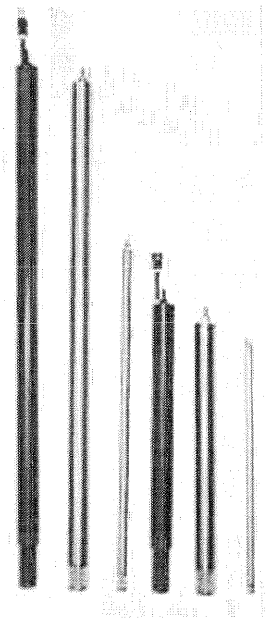
geotech

Geotech Bladder Pumps

Installation and Operation Manual



Rev. 2 3/12/02 Part # 21150035

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DOCUMENTATION CONVENTIONS

This manual uses the following conventions to present information:

WARNING

An exclamation point icon indicates a **WARNING** of a situation or condition that could lead to personal injury or death. You should not proceed until you read and thoroughly understand the **WARNING** message.

CAUTION

A raised hand icon indicates **CAUTION** information that relates to a situation or condition that could lead to equipment malfunction or damage. You should not proceed until you read and thoroughly understand the **CAUTION** message.

NOTE

A note icon indicates **NOTE** information. Notes provide additional or supplementary information about an activity or concept.

Chapter 1: System Description

Function and Theory

Geotech's pneumatic Bladder Pumps operate with a unique action, ideal for both, gentle low-flow sampling and high flow rate purging. Timed on/off cycles of compressed air alternately squeeze the flexible bladder to displace water out of the pump to the surface and exhaust allowing the pump to refill. Fluid enters the pump through the fluid inlet check valve at the bottom of the pump body, via hydrostatic pressure (automatically by submergence). The bladder then fills with fluid. Compressed air enters the space between the bladder and the interior of the pump wall housing. The intake check valve closes and the discharge check valve opens. The compressed air squeezes the bladder, pushing the fluid to the surface. The discharge check valve prevents back flow from the discharge tubing. Driven by the GEOCONTROLLER 2, this cycle automatically repeats.

Compressed air does not contact the sample! The bladder prevents contact between the pump drive air and the sample.

System Components

The GEOTECH Bladder Pump consists of three parts. The Bladder Cartridge Assembly, the Pump Housing, and the Intake Screen.

Bladder Cartridge Assembly

Geotech's bladder cartridge assembly is factory assembled and tested, and is designed to be field replaceable (see figure 1).

The cartridge assembly components consist of an upper and lower head constructed of virgin grade PTFE, (for bladder pump models GEO1.66PVC36 and GEO1.66PVC18 the upper and lower heads are constructed of NSF-grade PVC, extruded with no markings or lubricants). The internal flow tubes are constructed of electro polished 316 stainless steel, or NSF-grade PVC. The bladder material is constructed of inert virgin grade polymer resins, (proprietary resin grade PTFE – G303).

The bladder tube is assembled using a 316 stainless steel clamp, providing a true zero leak seal.

Housing

The bladder pump housing is constructed of electro polished 316 Stainless Steel. The housing components consist of threaded top and bottom caps, and the housing tube. For bladder pump models GEO1.66PVC36 and GEO1.66PVC18 the housing is constructed of NSF-grade PVC. Viton O-rings provide the high pressure seals between the end caps and the housing tube.

Intake screen

The intake filter screen is constructed of 316 Stainless Steel and is easily removable for field maintenance. For models Geo 1.66 PVC36 and Geo 1.66 PVC18, the intake screen is constructed of NSF-Grade PVC. The intake filter screen is intended to protect and extend the life of the bladder material (see warranty).

Figure 1 – SS Bladder Pump Assembly Figure 2 – PVC Bladder Pump Assembly

Chapter 2: System Installation

Bladder Pump

Geotech's Bladder Pumps are engineered for easy installation and use. Dedicated Bladder Pumps are shipped from GEOTECH with the tubing attached. Well identifications (supplied by customer) are located on tags connected to the tubing, and on the tubing bags.

Upon reaching the well head, connect the air line tubing to air line connection at the top of the Bladder Pump (see figure 3). The air line is smaller than the sample line. Next attach the sample line to the sample line connection at the top of pump (see figure 3).

The optional Bladder Pump Hanger is attached to the Quick Link on the safety cable and to the Pump Hanger. Carefully lower the Bladder Pump into the well using the reverse coil method to avoid kinking, until the well cap seats.

Reverse Coil Method (see figure 4)

When lowering the pump into the well it is important to reverse the natural bend of the coiled tubing so that the tubing will straighten out as it is lowered. As the pump and tubing are lowered down into the well, the direction of the bend should be reversed from the direction in which it is coiled up. If the tubing is allowed to uncoil naturally and the natural bend not interrupted, the tubing will continue its coil into the well. Using the reverse coil method will avoid hang-ups or difficulty in lowering the pump into the well, especially when the well is not completely vertical, or has come out of alignment for any reason.

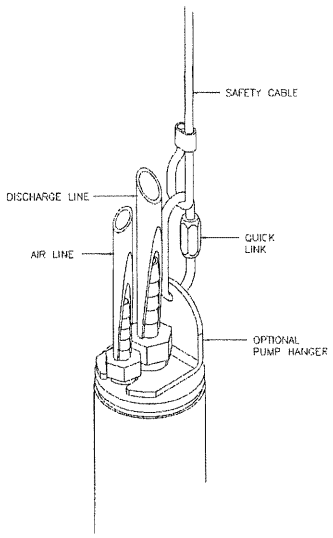


Figure 3

Figure 4 – Reverse Coil Method

Chapter 3: System Operation

Bladder Pump Operation

Fluid enters the pump through the fluid inlet check valve at the bottom of the pump body, and the bladder fills with fluid. Compressed air enters the space between the bladder and the interior of the pump wall housing, the inlet check valve closes and the discharge check valve opens. The compressed air squeezes the bladder pushing the fluid to the surface. The discharge check valve prevents backflow from the discharge tubing.

Selecting an Air Source

The following explanation is based on the Model GEO1.66SS36 with a .170 ID air supply tubing. To determine the required capacity of the air source used, calculate the air consumption as follows. With 100 ft. of air line tubing in or out of the well, the air consumption is 125 cubic inches per cycle, with 6 cycles per minute (average).

Example: For 100 ft. of tubing you will need 125 cu. in. x 6 per min. which equals 750 cu. in. / min. or 45,000 cu. in. / hr. For each additional 100 ft. add 59 cu. in. If you plan to use an air compressor we advise that you use one with a reserve tank to insure proper air supply to the pump. If you plan to use a Nitrogen Tank, see figure 9 for Nitrogen Tank Volume vs. Bladder Pump consumption.

Determining PSI

Determine the air pressure needed to operate the Bladder Pump based on the length of the air supply line to the pump (well depth). Use the simplified formula of (1/2 PSI per foot) + 10 PSI for friction.

Example: For a pump 100 ft. away from the air source, uses 100 ft. divided by 2 then add 10. This equals 60 PSI (100' / 2 + 10 = 60 PSI).

The additional 10 PSI is to account for the pump itself and friction loss along the air line tubing. When the length of the air line to the Bladder Pump is 50 ft. or less, the additional 10 PSI need not be added.
To determine minimum operating pressures for the specific Bladder Pump model you are using, consult pumps specifications. Typically the minimum operating pressure will be 5 PSI above static head.

Example: Bladder Pump depth is 50 ft. 50 / 2 = 25 + 5 = 30 PSI.

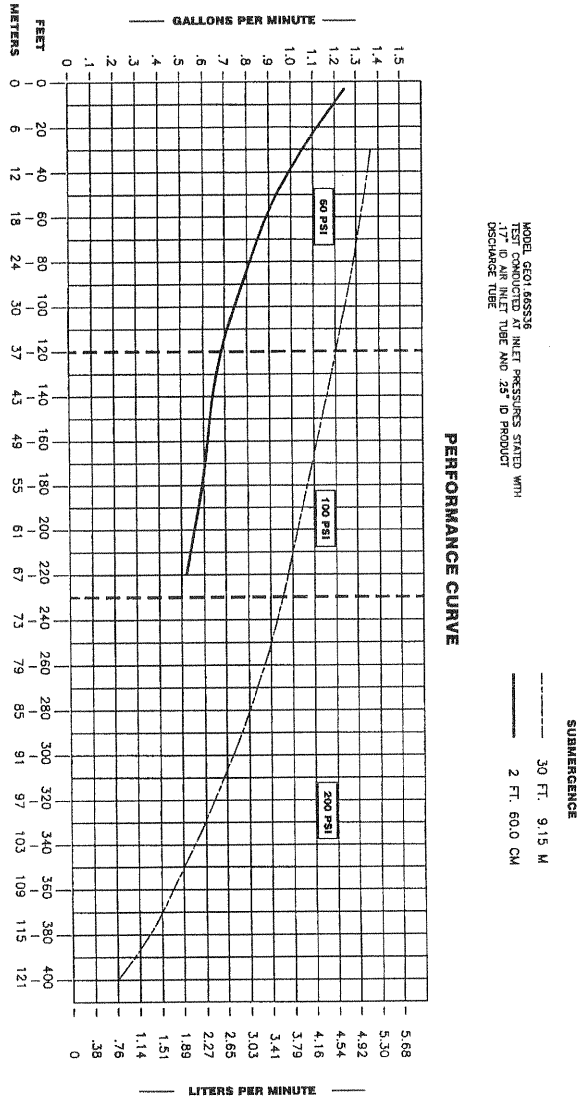
The formulas stated above are not absolute, and are meant to provide baseline information.

Flowrates

Flow rates are based on Geotech's models GEO1.66ss36 Stainless Steel Bladder Pump, and GEO1.66PVC36 PVC Bladder Pumps PERFORMANCE CURVE (see figures 5, 6, 7, & 8).

For determining the number of cycles it will take to receive sample fluid at the well head, see figure 9 CYCLES vs. DEPTH.

If using a nitrogen tank as an air source, see figure 10 NITROGEN TANK VOLUME vs. BLADDER PUMP CONSUMPTION.



* FLOW RATES WILL VARY WITH ON-SITE CONDITIONS

Figure 5 – Performance Curve

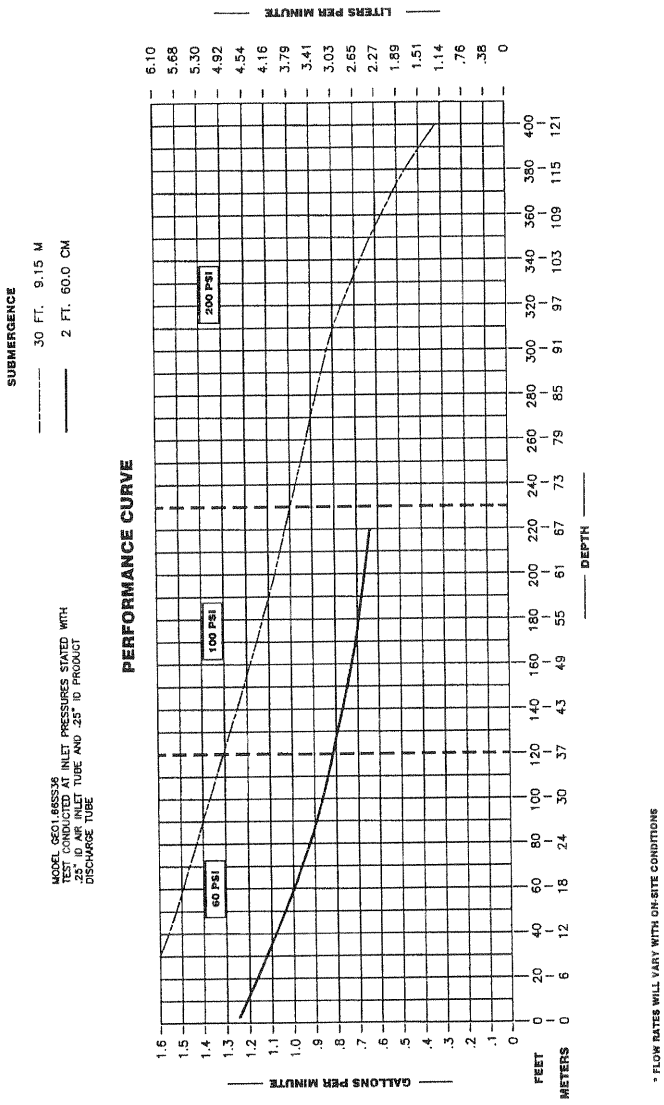


Figure 6 – Performance Curve

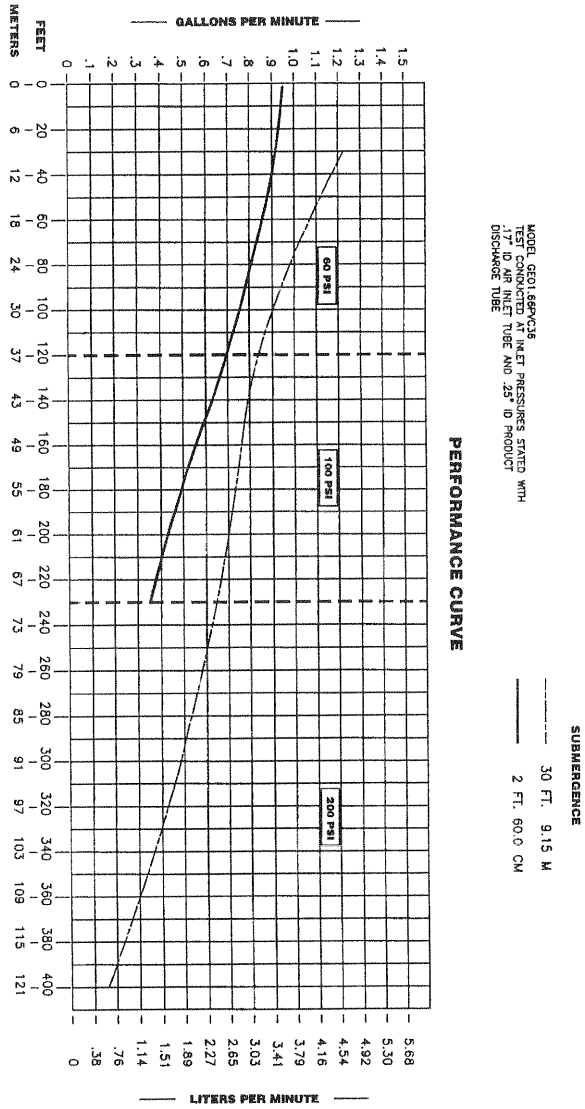


Figure 7 – Performance Curve

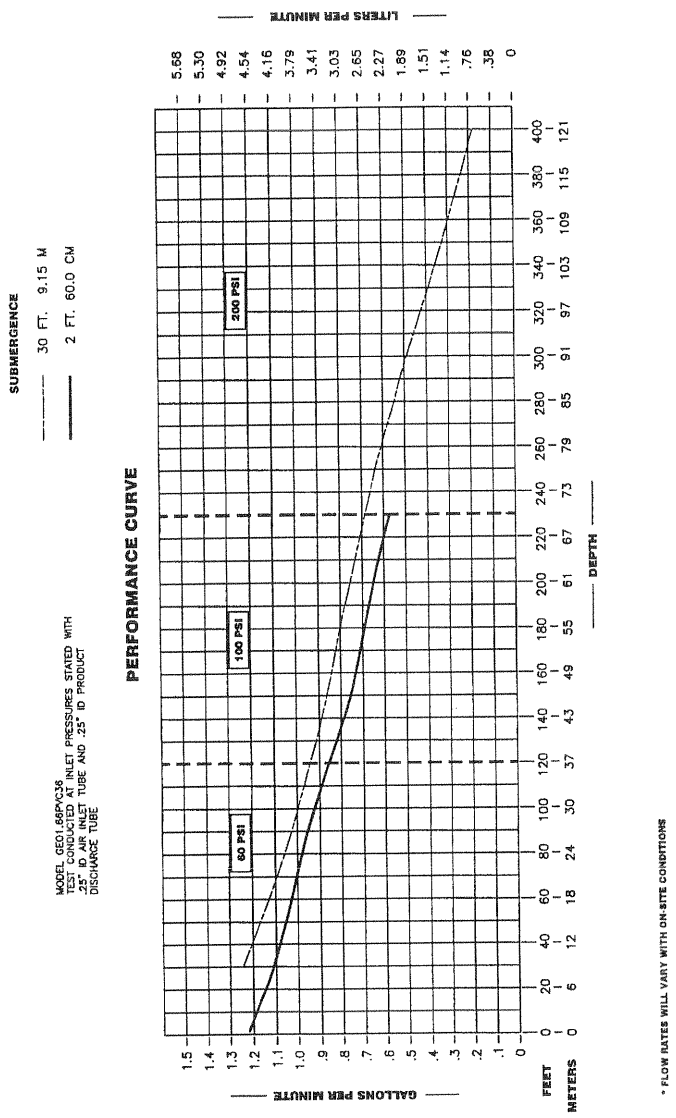


Figure 8 – Performance Curve

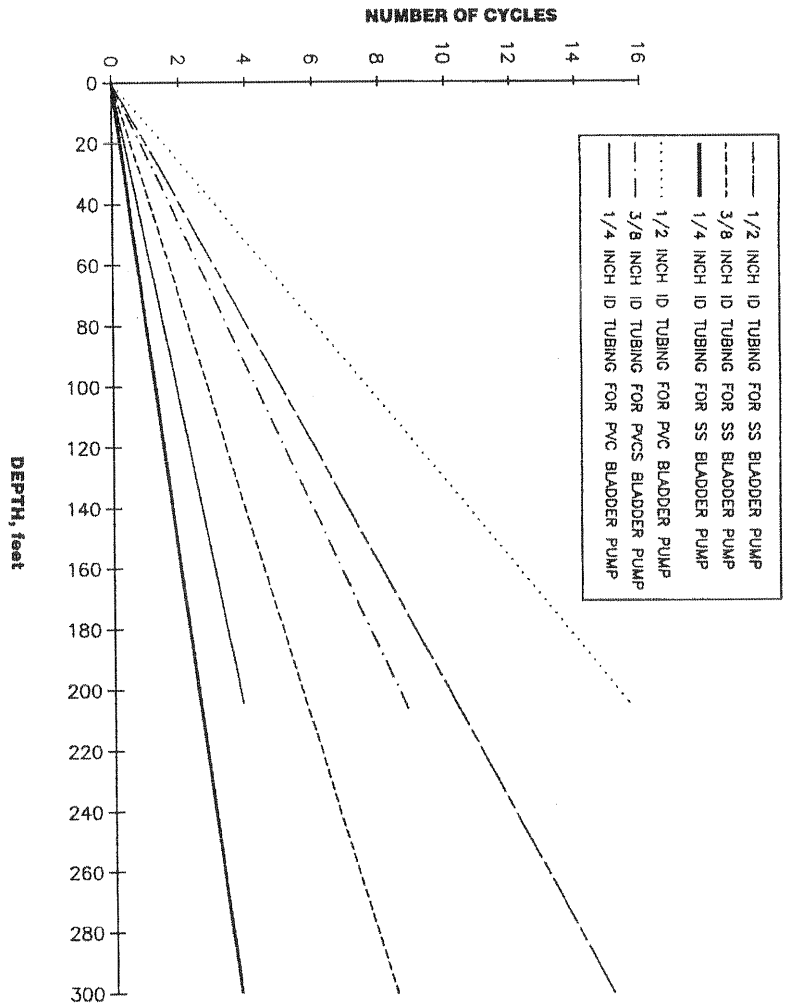


Figure 9 – Cycles vs. Depth

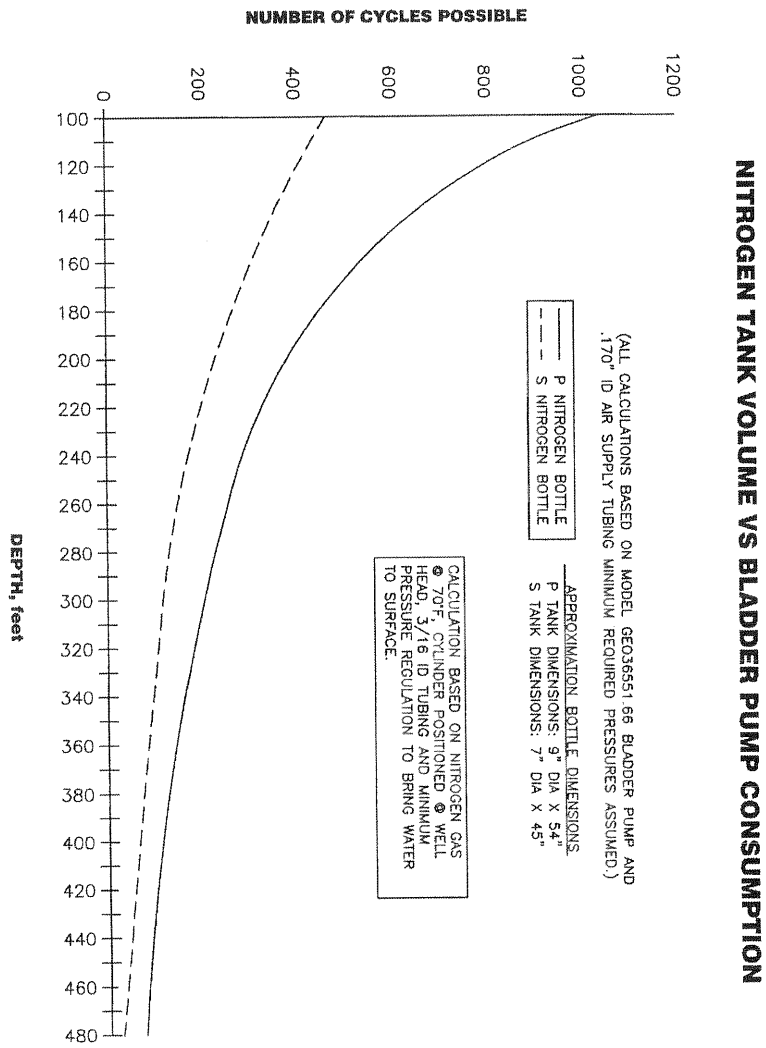


Figure 10 – Nitrogen Tank vs. Bladder Pump Consumption

Chapter 4: System Maintenance

Bladder Pump

As with any pump, scheduled or periodic maintenance should be performed, according to your sampling program and specific site conditions. Generally, the more turbid or sandy your water, the more often you should maintain and clean your pumps. (See System components, Bladder Cartridge Assembly). Disassemble Bladder Pump per instructions, decontaminate or replace as needed, then reassemble. Inspect all check balls for wear and replace as necessary. Inspect all O-rings for splits or cracks and replace as necessary.

Bladder Cartridge

When installing a new bladder cartridge, or performing maintenance on an existing cartridge use the following instructions:

- Pull pump from the well, it is not necessary to remove the air and sample lines from the pump.
- (Models w/screens) Using an Allen head tool, remove the shoulder bolts from the intake screen cap (see figure 1).
- Using the Spanner tool, while holding pump body, with your hand or with a strap wrench, use a spanner tool to turn lower head in a counter clockwise direction and remove. Pump head will be very snug due to the high pressure O-ring seal. Once the seal is broken, the lower head will turn very easily (see figure 12).
- The internal bladder cartridge can now be removed for maintenance or replacement. Gently tap the tube housing on a firm wood like surface until the cartridge drops from the upper head seal. Reach into the tube with one or two fingers and pull the cartridge free.
- Before replacing lower pump head, always check o-rings for rips or cracks and replace as necessary.
- For models without intake screens, use the Spanner tool provided for lower head removal (see figure 12).

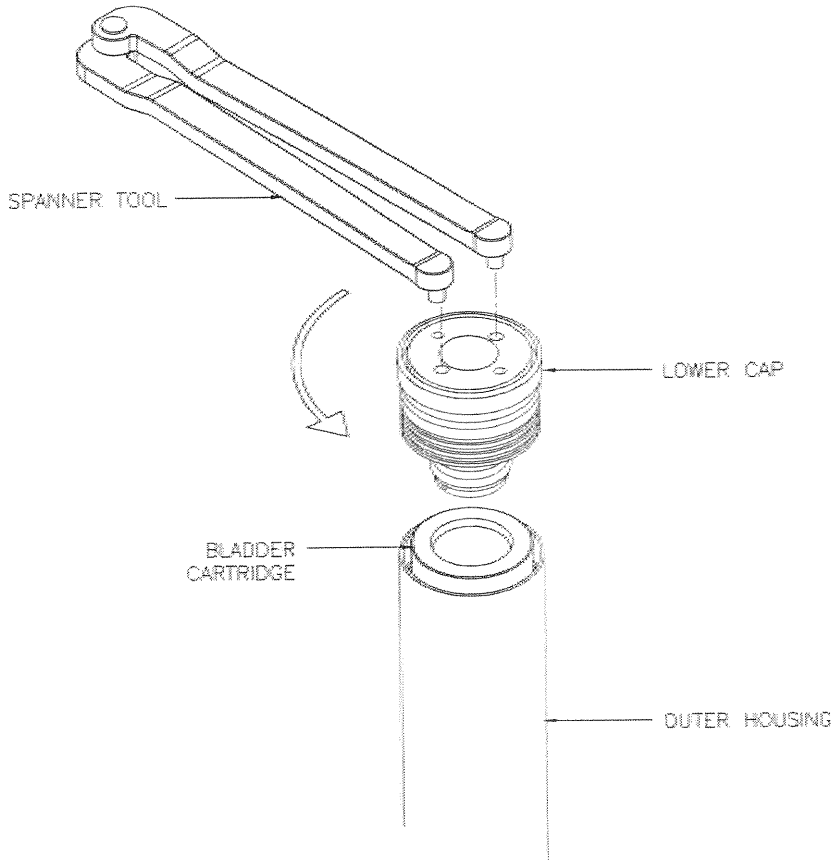


Figure 11

Chapter 5: System Troubleshooting

Bladder Pump: *Troubleshooting*

Problem:	Solutions:
Air is cycling thru controller, but will not pump…	1) Charge and exhaust times are not set correctly. Check and adjust charge and exhaust cycle times (i.e. if charge time is too long or if exhaust and charge time is too short). 2) Possible compromise in air line tubing. Check air line pump for leaks. If needed, repair using compression union or replace tubing. 3) Check pump intake screen for blockage and clean as needed.
Controller is cycling but the pump stops producing water…	1) Check drawdown level of water in the well. Ensure the pump is fully submerged and off of the bottom of the well. 2) Check psi at the regulator and adjust as necessary (see page 8). 3) Check for kinks in the discharge line. 4) Check pump intake screen for obstructions. 5) Charge time is too long or exhaust time is too short; causes pressure build up in pump, causing the pump not to fill. 6) Check power source, assure a strong reliable power supply. If using and old or weak battery, the control valves may not operate properly.

System Troubleshooting cont...

Getting air bubbles in sample line…	1) Over charging pump. Reduce charge cycle time so that charge cycle ends as fluid discharge trails off. Inspect pump for compromised bladder or o-rings. 2) Pump is being over pressurized (PVC pump). Reduce psi to what is necessary to overcome pumping head (see page 8 for determining psi). 3) Check discharge line for holes or kinks. Repair using compression union or replace tubing.
Discharge line drains back into pump…	1) Remove Hosebarb on pump discharge outlet. Check the check ball seat for debris. Clean and re-install.

Chapter 6: System Specifications

	GEO1.66SS36	GEO1.66SS18	GEO1.66PVC36
Pump Housing	SS, 316	SS, 316	PVC
Pump Ends	Virgin PTFE	Virgin PTFE	PVC
Bladder Matl.	Virgin PTFE Proprietary resin Grade (G303)	Virgin PTFE Proprietary resin grade (G303)	Virgin PTFE (Proprietary resin grade G303)
O.D.:	1.66"/4.2cm	1.66"/4.2cm	1.66"/4.2cm
Length: w/o screen	36"/91.4cm	18"/45.7cm	36"/91.4cm
Length: w/screen	38"/96.5cm	20"/51cm	___
Weight	5lb/1.9Kg.	2.5lb/0.93Kg	3.6lb/1.3Kg
Volume/Cycle	21.1oz./625ml	10.5oz./313ml	13.8oz.408ml
Max. Flowrate*	1.25gpm/4.7lpm	.65gpm/2.4lpm	.97gpm/3.7lpm
Min. Well I.D.	2"/50mm	2"/50mm	2"/50mm
Operating Press.	10-450psi/.7-31 bar	10-450psi/.7-31bar	10-110psi/.7-7.5 bar
Min. Operating Range	5psi/.34bar above static head	5psi/.34bar above static head	5psi/.34bar above static head
Maximum Depth **	1000'/305m	1000'/305m	250'/76.2M

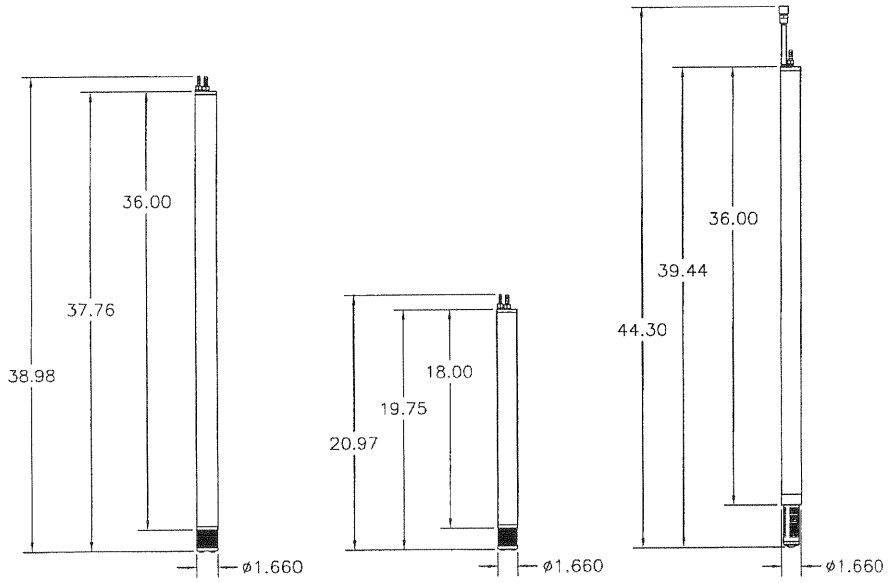
* Flow rate determined @ 2ft/60cm submergence

** With the use of a drop tube, maximum depth is increased

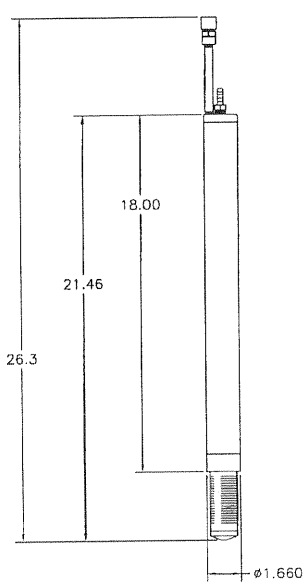
System Specifications

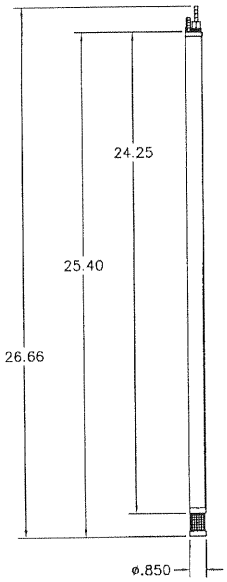
	GEO1.66PVC18	GEO850.SS24	GEO675.SS18
Pump Housing	PVC	SS, 316	SS, 316
Pump Ends	PVC	Virgin PTFE	Electropolished SS 316
Bladder Matl.	Virgin PTFE (Proprietary resin grade G303)	Virgin PTFE (Proprietary resin grade G303)	Virgin PTFE (Proprietary resin grade G303)
O.D.:	1.66"/4.2cm	.850"/2.2cm	.675"/1.7cm
Length: w/o screen	18"/45.7cm	24"/61cm	N/A
Length: w/screen	22"/55.9cm	25"/63.5cm	18"
Weight	1.8lb/.67Kg	1.6/.60Kg	.83lb/.38Kg
Volume/Cycle	6.9oz./204ml	2.1oz./59.6ml	1.35oz./38.4ml
Max. Flowrate*	.53gpm/2.0lpm	.10gpm/.36lpm	.05gpm/.19lpm
Min. Well I.D.	2"/25mm	1.00"/25mm	.75"/19mm
Operating Press.	10-110psi/.7-7.5bar	10-110psi/.7-7.5bar	10-110psi/.7-7.5bar
Min. Operating Range	5psi/.34bar above static head	5psi/.34bar above static head	5psi/.34bar above static head
Maximum Depth **	250'/76.2m	250'/76.2m	250'/76.2m

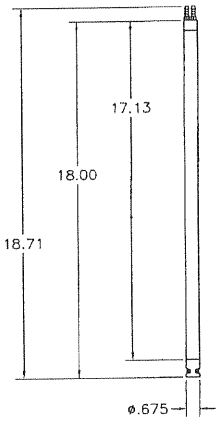
Chapter 7: System Schematic



GEO1.66SS36 GEO1.66SS18 GEO1.66PVC36







GEO1.66PVC18 GEO850.SS24 GEO675.SS18

Chapter 8: Replacement Parts List

Model GEO1.66SS36

QTY/ASSY	DESCRIPTION	PART #
1	Bladder Cartridge	51150100
1	Cap, Upper	11150104
1	Cap, Lower	11150107
1	Screen, Intake	11150109
2	Bolts, Shoulder	17200241
1	Hose barb, Sample out	11150106
1	Hose barb, Air in	17200241
1	Check ball, Upper	17500081
1	Check ball, Lower	17500082
1	O-Ring Viton cap/upper lower	17500104
2	O-Ring Viton cap/upper head interface	17500103
2	O-Ring Viton cap/lower head interface	17500106

MODEL GEO1.66SS18

QTY/ASSY	DESCRIPTION	PART #
1	Bladder Cartridge	51150106
1	Cap, Upper	11150104
1	Cap, Lower	11150107
1	Screen, Intake	11150109
2	Bolts, Shoulder	17200241
1	Hose barb, Sample out	11150106
1	Hose barb, Air in	21150019
1	Check ball Upper	17500081
1	Check ball Lower	17500082
1	O-Ring Viton cap/upper lower	17500104
2	O-Ring Viton cap/upper head interface	17500103
2	O-Ring Viton cap/lower head interface	17500106

Model GEO1.66PVC36

QTY/ASSY	DESCRIPTION	PART #
1	Bladder Cartridge	51150107
1	Cap, Upper	11150128
1	Cap, Lower	11150129
1	Screen, Intake	11150109
2	Cap Screen Intake	11150131
1	Hose barb, Sample out	11150134
1	Hose barb, Air in	17200248
1	Check ball, PVC Upper/lower	17500115
1	O-Ring, Viton cap/upper/lower	17500120
1	O-Ring Viton cap/head interface	17500119

MODEL GEO1.66PVC18

QTY/ASSY	DESCRIPTION	PART #
1	Bladder Cartridge	51150108
1	Cap, Upper	11150128
1	Cap, Lower	11150129
1	Screen, Intake	11150130
2	Cap, screen intake	11150131
1	Hose barb, Sample out	11150134
1	Hose barb, Air in	17200248
1	Check, PVC Upper/lower	17500115
1	O-Ring Viton cap/upper lower	17500120
2	O-Ring Viton cap/head interface	17500119

Model GEO850.SS24

QTY/ASSY	DESCRIPTION	PART #
1	Bladder Cartridge	51150103
1	Cap, Upper	11150111
1	Cap, Lower	11150112
1	Screen, Intake	11150119
2	Screw 4-40 x 1	17200246
1	Hose barb, Sample out	11150118
1	Hose barb, Air in	17200245
1	Check ball	17500079
1	O-Ring, Viton cap/upper/lower	17500112
2	O-Ring Viton cap/upper head interface	17500119
2	O-Ring Viton cap/lower head interface	17500111

MODEL GEO.675SS18

QTY/ASSY	DESCRIPTION	PART #
1	Bladder Cartridge	51150116
1	Cap, Upper	21150030
1	Cap, Lower	21150031
2	Hose barb, air sample	17200245
1	Check ball, upper	ppm130001
1	Check ball, lower	17500079
1	Disc Teflon	21150033
1	Snapring	11150182
1	O-Ring, Bladder Cap, Upper	11150183
1	O-Ring, Bladder Cap, Lower	17500183
2	O-Ring, cap housing	11150184

Notes

The Warranty

For a period of one (1) year from date of first sale, product is warranted to be free from defects in materials and workmanship. Geotech agrees to repair or replace, at Geotech's option, the portion proving defective, or at our option to refund the purchase price thereof. Geotech will have no warranty obligation if the product is subjected to abuse, misuse, or inability to use this product. User assumes all other risk, if any, including the risk of injury, loss, or damage, direct or consequential, arising out of the use, misuse, or inability to use this product. User agrees to use, maintain and install product in accordance with recommendations and instructions. User is responsible for transportation charges connected to the repair or replacement of product under this warranty.

Equipment Return Policy

A Return Material Authorization number (RMA #) is required prior to return of any equipment to our facilities, please call 800 number for appropriate location. An RMA # will be issued upon receipt of your request to return equipment, which should include reasons for the return. Your return shipment to us must have this RMA # clearly marked on the outside of the package. Proof of date of purchase is required for processing of all warranty requests.

This policy applies to both equipment sales and repair orders.

FOR A RETURN MATERIAL AUTHORIZATION, PLEASE CALL OUR SERVICE DEPARTMENT AT 1-800-833-7958 OR 1-800-275-5325.

Model Number: _____

Serial Number: _____

Date: _____

Equipment Decontamination

Prior to return, all equipment must be thoroughly cleaned and decontaminated. Please make note on RMA form, the use of equipment, contaminants equipment was exposed to, and decontamination solutions/methods used.

Geotech reserves the right to refuse any equipment not properly decontaminated. Geotech may also choose to decontaminate equipment for a fee, which will be applied to the repair order invoice.

Geotech Environmental Equipment, Inc
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